A Study of Babylonian Goal-Year Planetary Astronomy

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PhD Thesis

Department of Physics
University of Durham
2009

Abstract

Throughout the Late Babylonian Period, Mesopotamian astronomers made nightly observations of the planets, Moon and stars. Based on these observations, they developed several different techniques for predicting future astronomical events. The present study aims to improve our understanding of a particular empirical method of prediction, which made use of planetary periods – a period of time over which a planet's motion recurs very closely – to predict that planet's future motion.

Various planetary periods are referred to in many Late Babylonian astronomical texts. By collecting together these periods and analysing their effectiveness, it was found that, generally, the most effective of the planetary periods were those which were used in the production of a particular type of text known as a Goal-Year Text. The Goal-Year Texts contain excerpts of astronomical observational records, with the planetary records having been taken from particular observation years with these planetary periods in mind – such that each planet's motion will recur during the same, specific, future year. It has been suggested that they form an intermediate step towards the compilation of the non-mathematical predictive texts known as Almanacs and Normal Star Almanacs.

An analysis of theoretically calculated dates of planetary events showed that, if the Goal-Year Texts were to be used as a source for making empirical predictions, particular corrections (specific to each planet) would need to be applied to the dates of the planetary records found in the Goal-Year Texts. These corrections take the form of regular corrections to the day of an event (a "date correction"), and more irregular corrections of ± 1 month (a "month shift"). An extensive investigation of the Babylonian non-mathematical texts demonstrated that the observed differences in the dates of events, when comparing equivalent records in all known extant Almanacs and Normal Star Almanacs with those in the Goal-Year Texts, were extremely consistent with theoretical expectations. This lends considerable support to the theory that the Goal-Year Texts' records formed the "raw data" used in the compilation of the Almanacs and Normal Star Almanacs.

It was also possible to analyse several other aspects of Late Babylonian non-mathematical astronomy during the course of this study. These topics include the usage of particular stars in the predictive texts, the meaning of certain terminology found in records of the Babylonian zodiacal signs, and the specific issues related to the planet Mercury's periods of visibility and invisibility. Therefore, this investigation enhances many aspects of our knowledge of Late Babylonian astronomical practices.

Declaration

The work described in this thesis was undertaken between 2006 and 2009 while the author was a research student under the supervision of Professor John Steele in the Department of Physics at the University of Durham. This work has not been submitted for any other degree at the University of Durham or any other University.

Portions of this work have appeared in the following papers:

J. M. Steele & J. M. K. Gray (2007), A Study of Babylonian Observations Involving the Zodiac, *Journal for the History of Astronomy* 38, 443-458

J. M. K. Gray & J. M. Steele (2008), Studies on Babylonian goal-year astronomy I: a comparison between planetary data in Goal-Year Texts, Almanacs and Normal Star Almanacs, *Archive for History of Exact Sciences* 62, 553-600

J. M. K. Gray & J. M. Steele (2009), Studies on Babylonian goal-year astronomy II: the Babylonian calendar and goal-year methods of prediction, *Archive for History of Exact Sciences*, in press.

Acknowledgments

Many thanks are due to my supervisor, Professor John Steele, for his help and guidance over the last four years. I am also very grateful to the Science and Technologies Research Council for funding my research, and to colleagues in Durham University's departments of Physics, Classics and Ancient History, and Philosophy for their interest in my work.

I have also benefited from the support of many other people, and the knowledge they have shared with me. Thanks especially to the following for their provision of, variously, useful discussions, books, data, and copies of unpublished texts: Prof. Lis Brack-Bernsen, Dr. John Britton, Prof. Hermann Hunger, Prof. Alexander Jones, Prof. Norbert Roughton, and Mr. Christopher Walker.

Finally, thank you to my family and friends who encouraged me to get this far!

Contents

Chapter 1

Introduction

1.1 General Introduction

The origins of several aspects of modern western astronomy are found in the astronomical practices developed 2000-3000 years ago in the region of Mesopotamia. Concepts which were first used in Mesopotamia, such as sexagesimal number systems, still form part of our everyday lives.[1] Various elements of Mesopotamian astronomical knowledge spread to other regions, by communication with astronomers from Greece and other cultures.[2]

The vast majority of extant Mesopotamian astronomical texts date to the Late Babylonian Period (the period between approximately 750BC – 75AD), mostly from the city of Babylon (with a much smaller number from the city of Uruk). We can divide the astronomical texts from this period into three (interconnected) areas – non-mathematical observations and predictions, mathematical predictions, and astrology/horoscopes – which shall be described in detail later.

The main aim of this study is to understand the relationship between the various types of texts which are classed as non-mathematical. In particular, my goal is to understand the uses of one of the classifications of non-mathematical text: the Goal-Year Text.[3] Chapter 2 describes the different classifications of non-mathematical text from the period and their contents in detail and, as we shall see, Goal-Year Texts are divided into sections which each consist of observations relating to a particular planet (or to the Moon) from a particular year. Note that the scope of this work is to investigate the textual relationships by study of the *planetary* observations and predictions; as we shall see later, observations and predictions of lunar events have been thoroughly investigated in recent years (see §1.3.2.2), against the comparatively lower attention which the non-mathematical planetary records have attracted. Therefore in this work my focus will always be concerning the planetary rather than the lunar records.

The motion of the planets is extremely periodic, and so a given planet's motion will recur an (approximately) exact number of Babylonian years later. Therefore the Goal-Year Texts copy observational planetary records from particular years, to make use of these planetary periods (which will of course be different for each planet). The years chosen are such that during a specific future year (known as the goal year), each of the planets will have exactly completed a period over which its motion recurs.

In other words, an approximate record of events for the goal year can be predicted empirically by being aware of periods over which planetary events recur, and extracting specific observational records from those years accordingly. This non-mathematical method of making empirical predictions may also be referred to as "Goal-Year astronomy"; even though the Goal-Year Texts themselves are not found until the late 3rd century BC, these Goal-Year type empirical methods of prediction are observed across the entire Late Babylonian Period, from the earliest extant texts. Chapter 4 collects together the

[1] For general overviews of Mesopotamian astronomy and its legacies, see for example Neugebauer (1969), Pingree (1998), Steele (2008).
[2] Various aspects of this knowledge transfer (both to and from Mesopotamia) are discussed in, for example, Neugebauer (1963 and 1989), Jones (1991), Toomer (1988), Steele (2007c).
[3] The names and classifications of the non-mathematical texts are explained in Sachs (1948).

planetary periods recorded in these texts, and investigates ways we could determine how effective the planetary periods were in practice.

It has been suggested that the Goal-Year Texts form the "raw data" from which the non-mathematical predictive texts were produced – this theory is analysed in depth in Chapters 5 and 6. As we shall see, Goal-Year planetary astronomy has generally attracted somewhat less attention than other aspects of Late Babylonian non-mathematical or mathematical astronomy (which will be outlined later in the chapter).

The fact that each planet's records in a Goal-Year Text date to a different observations year, and that these years relate to the planets' periods of motion, was discovered in some of the earliest investigations of these texts. This knowledge is referred to in some of the earliest studies of Babylonian astronomy by Epping[4] and Kugler[5] (who calls the Goal-Year Texts "planetarischen Hilfstafeln").

In Sachs' *Classification of the Babylonian Tablets of the Seleucid Period* he gives the Goal-Year Texts, along with the other types of non-mathematical texts, their current name, and considers at length what the source of the records in the various non-mathematical predictive texts may have been.[6] He suggests, and discusses the problems associated with, several potential sources, described below:

> i) that the predictive records come from the ephemerides in the "Astronomical Tables" (i.e. what we would now call the *Astronomical Cuneiform Texts* (*ACT*)[7] – see §1.3.3 for a description of these),
> ii) that the predictive records come from the observational records in the Goal-Year Texts (of uncertain source themselves),
> iii) that both of the above sources together were used in the production of the non-mathematical predictions,
> iv) that the predictive texts known as Normal Star Almanacs used the Goal-Year Texts, and the predictive texts known as Almanacs used the *ACT* data.

Each of these suggestions will be analysed in the following chapters.

More recent researchers have tended to agree with Sachs' assessment of the predictive texts' potential sources. Hunger states that the types of records in the Goal-Year Texts and the predictive texts could well have come from the same source.[8] However, he compares records in the Goal-Year Texts and the predictive texts and finds a considerable number of differences, showing that even if there exists a relationship between these texts, it is not as simple as just copying the records across. As Chapters 4 and 5 will discuss, we would expect these differences to be found.

Conversely, Hunger & Pingree point out the differences between the contents of the Goal-Year Texts and the predictive texts, suggesting that "no one of them derives from another".[9] The main difference they find between the text types' contents seems to be that the predictive texts contain computed dates of, eg, solstices and eclipses and the Goal-Year Texts do not. However, since these dates were always computed according to a particular scheme, as we shall see in Chapter 2, this does not cast doubt on the possibility of Goal-

[4] Epping (1889).
[5] Kugler (1907), p 19 and pp 84-87.
[6] Sachs (1948), pp 287-290.
[7] Neugebauer (1955).
[8] Hunger (1999).
[9] Hunger & Pingree (1999), p. 173.

Year Texts' uses in predicting planetary events. Hunger & Pingree's point is presumably also that the records in the extant predictive texts could not have come from the records in the extant observational texts, but we must surely assume that the number of texts available to the Babylonian astronomers must be considerably higher than the number which have survived to the present day. See Figure 2.1 in the following chapter for an illustration of the relatively low numbers of non-mathematical text extant nowadays.

In his introduction to the recent volume of translations of Goal-Year Texts, Hunger agrees with this suggestion that specific records may have derived from texts which were available to the Babylonian astronomers but which have not yet been excavated and become available to us, or which have been destroyed. He also agrees with Sachs that the Goal-Year Texts' purpose must have been "obvious: to make predictions for the Goal year".[10]

Most recently, Steele has considered *Goal-Year Periods and Their Use in Predicting Planetary Phenomena*.[11] In this paper, he discusses the use of the planetary periods in the Goal-Year Texts, and in other texts, to predict planetary events. He also discusses the corrections which need to be applied to the planetary periods, in terms of days or degrees of longitude, to allow for the fact that the planets' periods are not necessarily an exact number of Babylonian years long.[12] Chapters 4 and 5 will analyse these date corrections.

1.2 Calendars and chronology

1.2.1 Mesopotamian chronology

The point marking the beginning of the Late Babylonian Period is commonly taken to be the accession of Nabonassar in 747 BC. Ptolemy uses this date as the beginning of his "Canon of Kings"[13] and states that the Babylonian observations he uses in the *Almagest* begin from Nabonassar's reign.[14] Mesopotamian texts generally record dates by the use of regnal years, i.e. the number of years since the current king came to the throne. Without independent corroboration of the dates of a king's reign (or by means of a dateable astronomical or historical event) it can be extremely difficult to ascertain when exactly a text was written in terms of our present-day BC-AD calendar, and this has led to the dates of entire periods of history being disputed.

Fortunately, the dates of kings' reigns during the Late Babylonian Period are considered secure. This is due in a large part to Ptolemy's "Canon of Kings", which lists the names of all the Late Babylonian kings, along with the length of their reign and the total number of years between their reign and Nabonassar's accession in each case.[15]

A summary of the Late Babylonian Period's chronology is given in Table 1.1. The table shows the names, lengths of reigns, and date of the first year of each reign for kings during the period. From Nabopolassar onwards the names and dates are taken from Parker & Dubberstein's chronological tables, and before this point the names and dates are taken from J. A. Brinkman's "Mesopotamian Chronology" and Ptolemy's Canon of Kings.[16] It can be seen from the Table that Parker & Dubberstein's dates occasionally include overlapping reigns of kings or multiple accessions in the same year, presumably due to

[10] Hunger (2006), p. XII.
[11] Steele (2009, in press).
[12] See also Gray & Steele (2008).
[13] Depuydt (1995).
[14] *Almagest* III.7, translated in Toomer (1998), p. 166.
[15] Depuydt (1995), Hallo (1988). See also Walker (1999).
[16] Parker & Dubberstein (1956), Oppenheim (1964) p. 340, Toomer (1998) p. 11.

disputes about who the new monarch should be. Ptolemy's Canon does not include the details of these contests.

Note that Babylonian years begin and end in March or April of our calendar, so each Babylonian year will span part of two BC years. To reduce ambiguity, in the table I have given both BC years covered by the Babylonian year. Note also that kings' names are not listed in the table from 311 BC onwards because from that point the texts were not dated according to the current ruler, but according to the number of years since Seleucus I's accession in 311 BC. Once Babylon became part of the Parthian Empire in the mid-2nd century BC, dates were given according to the Arsacid Era (number of years since 247 BC) in addition to the Seleucid Era dates.

Empire	King	First year of reign (BC)	Years of reign
Neo-Assyrian	Nabonassar	747/746	14
	Nabu-nadin-zeri	733/732	2
	Nabu-šuma-ukin II	732/731	< 1
	Nabu-mukin-zeri	731/730	3
	Tiglath-Pileser/Pulu	728-727	2
	Shalmaneser/Ululaju	726/725	5
	Marduk-apla-iddin	721/720	12
	Šarru-ukin	709/708	5
	Interregnum	704/703	2
	Bel-ibni	702/701	3
	Aššur-nadin-šumi	699/698	6
	Nergal-ušezib	693/692	1
	Mušezib-Marduk	692/691	4
	Interregnum	688/687	8
	Ašur-aḫa-iddina	680/679	13
	Šamaš-šum-ukin	667/666	20
	Kandalanu	647/646	22
Neo-Babylonian	Nabopolassar	625/624	21
	Nebuchadnezzar II	604/603	43
	Amel-Marduk	561/560	2
	Nergal-Shar-Usar	559/558	4
	Labashi-Marduk	556/555	< 1
	Nabunaid	555/554	17
Persian	Cyrus	538/537	9
	Cambyses	529/528	8
	Bardiya	522/521	< 1
	Nebuchadnezzar III	522/521	< 1
	Nebuchadnezzar IV	521/520	< 1
	Darius I	521/520	36
	Xerxes	485/484	21
	Artaxerxes I	464/463	41
	Darius II	423/422	19
	Artaxerxes II	404/403	46
	Artaxerxes III	358/357	21
	Arses	337/336	2
Macedonian	Alexander III	336/335	14
Persian	Darius III	335/334	5
Macedonian	Philip Arrhidaeus	323/322	8
	Alexander IV	316/315	10
	Seleucid Era	311/310	onwards

Table 1.1: the names and regnal dates of rulers of Babylon during the Late Babylonian Period.

1.2.2 Calendrical systems

The basic unit of the Mesopotamian calendar was the lunar month. The first day of a new month was marked by the first visibility of the new lunar crescent at sunset, which provided an easily-observable way to document the passage of time.[17] However, the synodic month is approximately 29.53 days long on average, and therefore lunar months varied between 29 or 30 days long in no particularly regular sequence, making some administrative functions unnecessarily complex. It has been shown that, from around 2600 BC to 300 BC, there were therefore *two* calendrical systems in use simultaneously: the civil calendar, based on the lunar month; and the administrative calendar, based on ideal months which were always 30 days long.[18] The Late Babylonian astronomical texts always use the lunar calendar, denoting the different month lengths by stating whether each new month began 29 or 30 days after the previous one.[19]

Another complication of the lunar calendar is that there are not a whole number of lunar months in a solar year, leading quickly to a lack of connection between calendar dates and seasons. Some cultures had very successful calendrical systems where there was no association between time of year and calendar dates or months, and did not seem to mind that lack; for example, the calendar devised by the Egyptians, whose calendar year invariably had 365 days, was still in use in the Middle Ages.[20] However, in Mesopotamia the preference was for the new year to begin around the time of the vernal equinox. Twelve lunar months contain approximately 354 days, around eleven days short of a solar year. Therefore, from the 3rd millennium BC, an extra month was inserted into the Mesopotamian calendar every three years or so to keep the months and the seasons in step.[21]

Initially an intercalary month would be added into the calendar at any point of the year where it was deemed to be needed, but gradually intercalation schemes evolved. Around 480 BC the Metonic Cycle was introduced, which adds 7 intercalary months into specific years on a 19-year cycle.[22] This highly accurate intercalation scheme was used without alteration for the rest of the period. (Despite being named after a Greek philosopher, Meton of Athens, the 19-year cycle was in use in Babylonia first.[23])

With these two pieces of information – a confirmed chronology of dates of reigns (or starting date of an era) and the calendrical system in use at the time, it is possible to convert any Late Babylonian date into a date in the more modern Julian calendar. For example, Parker & Dubberstein's[24] conversion tables show the equivalence of dates in the two systems for years between 626 BC (the start of the Neo-Babylonian empire) and 75 AD. The two major caveats with using the dates from these tables are: firstly, that any conversion may be wrong by ±1 day when the tables incorrectly designate a month as full or hollow. Secondly, the tables generally follow the same 19-year sequence of intercalary months throughout the whole period, even though this sequence became fixed only around

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[17] As Britton (2007a), p. 130 remarks, month lengths recorded in the texts show that the criterion was first *visibility* of the lunar crescent rather than the subtly different first *observation* (which would lead to much longer months during periods of bad weather). Steele (2007b) shows that during the Seleucid Era the first day of a new month was always calculated in advance.

[18] Englund (1988), Brack-Bernsen (2007).

[19] Sachs & Hunger (1988), p. 20. The conventional terminology refers to 29-day months as "hollow" and 30-day months as "full".

[20] Neugebauer (1969), p. 81.

[21] Britton (2007a).

[22] Britton (2002).

[23] Bowen & Goldstein (1988).

[24] Parker & Dubberstein (1956).

480BC. This means that they occasionally erroneously include an intercalary month in a particular year where the textual evidence shows that it did not occur that year, but in the previous or following year.[25] In terms of dating events, there would simply be a disconnection of exactly a month between Parker & Dubberstein's dates and actual Babylonian dates, for the period between the expect intercalary month and the actual intercalary month, which would need to be taken into account.[26]

As previously stated, many cuneiform texts have become damaged in the intervening millennia since they were written. This leads to the fact that in many cases the date of a text has broken away, since the date tends to be recorded at the very beginning or end of the text. However, some of the time the date of even a broken text can be estimated or deduced. Firstly, the style of writing or the use of particular terminology will often demonstrate whether the text is from earlier or later periods of cuneiform history (although this will not in itself distinguish an old text from a later copy of an older text).

Secondly, astronomical or historical records on the texts can be analysed. A historical event corroborated by other sources, such as the death of Alexander the Great,[27] can yield a date, though this is comparatively rare. Much more common is dating a text by means of the astronomical positions and events. Naturally, planetary, lunar or solar phenomena tend to be periodic and so will not individually supply a unique date, but a number of events for the same month, say, will very quickly reduce the number of possible solutions.[28] The ease of finding a unique solution is improved by a record of a relatively rare event, such as a solar eclipse or an observation of Halley's comet.[29] The date of a Sirius date, an equinox or a solstice will also reduce the possible dates to one year in 19 because dates of these events were predicted on a 19-year scheme rather than being observed.[30]

One final note on the dating of texts: it is often difficult to know how to refer to Babylonian years (which span more than one Julian year, as we have seen) unambiguously. The terminology "747/746 BC" is unambiguous but can be cumbersome, and referring to, say, "Year 1 of Nabonassar" is not completely clear unless one is otherwise aware of the dates of the kings' reigns. A conventional way of referring to BC dates is to create a continuous sequence of years by referring to the year 1 BC as year 0, then the year 2 BC as -1, and so on; the first year of Nabonassar's reign, for example, would be the year -746/-745 in this terminology. The continuous sequence of years simplifies modern calculations involving ancient dates, although the terminology is not much less cumbersome than using BC dates.

Once the Seleucid Era begins, the Babylonian astronomers conventionally record the dates of all their texts according to the year of the era rather than by kings' reigns. This means that to establish the chronology of the Seleucid Era one only needs independent confirmation of one date (the starting point of the era, i.e. the accession of Seleucus I in 311 BC) rather than needing to be aware of the regnal dates of every ruler. From this point

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[25] See for example Britton (2007b), or the commentary to *ADART* Vol. V No. 59. (When making reference to a particular text translated by Sachs & Hunger (1988-2006), I will hereon refer to it as *ADART* Vol. m No. n).

[26] For more on the addition intercalary months and how this affects astronomical predictions, see Chapter 6.

[27] Laconically recorded by the Late Babylonian astronomers in *ADART* Vol. I No. -322B, Obv. 8': "The 29th, the king died".

[28] For a general discussion on dating texts, see Sachs & Hunger (1988), p. 19. A specific method of accurately dating texts based on sequences of lunar data has been devised by Huber, detailed in Huber & Britton (2007), Huber & Steele (2007).

[29] Stephenson & Walker (1985).

[30] Neugebauer (1948), Sachs (1952b). This is discussed further in the following chapter.

the difficulty of writing Babylonian years clearly and unambiguously is largely solved by giving the date of Seleucid Era texts as year "SE Y". Therefore I shall follow this terminology where possible.

1.3 Late Babylonian Astronomy

1.3.1 Overview of the development of astronomy in Mesopotamia

Let us now move on to the specific astronomical interests of the Late Babylonian scribes. As mentioned above, these fall into three main areas: non-mathematical astronomy, mathematical astronomy, and horoscopic astrology. First we shall briefly put the Late Babylonian astronomy and astronomers in context by looking at the development of astronomy in earlier periods of Mesopotamian history, particularly the long tradition of interpreting planetary omens.

It is not known exactly when occurrences such as unusual weather conditions or astronomical events began to be seen as messages from the gods in need of interpretation. The earliest records of such omens date from the early second millennium BC,[31] and their compilation into the vast omen collection *Enūma Anu Enlil* seems to have happened during the Middle Assyrian Period, in the early first millennium BC.[32] *Enūma Anu Enlil* consists of around 70 tablets, containing some 6000-7000 omens. The omens' format typically includes an "if" statement (the "protasis") involving events of the Moon, Sun, planets, stars or the weather, and a "then" statement (the "apodosis") determining the consequences to the king or the nation based on the event. Some texts also outline rituals which can be undertaken to ward off the effects of inauspicious omens.[33]

Concurrent with the compilation of these omen texts, we also find the rise of star catalogues. One of the earliest surviving examples, the *Three Stars Each*, dates to around 1100 BC. It divides the sky into three regions, assigning all the stars within a region to the god Enlil, Anu or Ea.[34] A later text which also contains a star catalogue is MUL.APIN, believed to have been compiled from records dating from around 1300 BC.[35] Many copies of MUL.APIN exist from across the entire Neo-Assyrian period, and it was being recopied as late as the Seleucid Era;[36] clearly, MUL.APIN was regarded as a significant text. It contains many astronomical and astrological sections, including a star catalogue, information on stars' heliacal risings, calendrical intercalation schemes and some omens.

By the 10th century BC Assyria became a dominant power in Mesopotamia and, in the 8th century BC, conquered Babylonia. From this period we find textual evidence that the king had in his service a number of scholars who were expected to report on and interpret ominous events. A large body of letters and reports were found in Nineveh's royal archives, written by scholars in Nineveh and in other cities around the region, and addressed to the king. Many of the texts are astrological in nature, often quoting a relevant omen from *Enūma Anu Enlil* in their reports – thus showing that *Enūma Anu Enlil* remained an important reference text during the Neo-Assyrian period, several hundred years after its compilation.[37]

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[31] Steele (2008), p. 31.
[32] Many of the tablets are translated and discussed in, variously, Reiner & Pingree (1981), Rochberg-Halton (1988a), van Soldt (1995).
[33] Hunger & Pingree (1999), pp. 5-26.
[34] van der Waerden (1974); Rogers (1998), p. 16.
[35] Schaefer (2007).
[36] Hunger & Pingree (1989), pp 10-12.
[37] Many of the texts are translated and commented on in Hunger (1992) and Parpola (1993). See also

Once Babylon became independent of Assyrian rule in the 7th century BC, the focus of astronomy changed. Unlike the astronomy of the Neo-Assyrian empire, where scholars were employed in many cities across the region, almost all astronomy from the Late Babylonian Period originates from the city of Babylon. The earliest "Diary" type collections of observations are found in this period, a tradition which in all probability grew from a desire to understand celestial motion, and hence predict ominous events, more effectively.

Impressively, the continuous tradition of astronomy continues for more than 800 years, even when the city of Babylon was captured: first by Cyrus the Great in 539BC, when it became part of the Persian Empire; then by Alexander the Great in 330BC, when it became part of the Macedonian Empire. Babylon's decline continued as Seleucus reportedly deported the city's population to the new royal city of Seleucia in 274 BC,[38] and around 126 BC Babylonia became conquered into the Parthian empire. Yet the astronomical tradition at Babylon continues in a (presumably) practically deserted city until the last dateable cuneiform texts in the late 1st century AD.

Who were the people responsible for compiling astronomical texts for so many centuries? McEwan describes the role of the ṭupšar *Enūma Anu Enlil* ("scribe of *Enūma Anu Enlil*"),[39] an official position at Babylon's Esagila temple. These scribes were, among other duties, astronomer/astrologers who were hired to "make the observations and give the calculations and measurements"[40]. It is interesting that the job title still referred to *Enūma Anu Enlil* well into the Greek period, when the tradition of interpreting omens had not been in practice for several centuries. It perhaps did not seem as vital to interpret omens concerning the king's fate once Babylon was under Persian rule and there were no more Mesopotamian kings. Instead, the 5th century BC sees the rise of another strand of interpretative astrology in the form of personal horoscopes.

By the Late Babylonian period, Akkadian had fallen out of usage as a spoken language in favour of Aramaic, yet the astronomical texts are still written in the traditional combination of Akkadian syllabic cuneiform and Sumerian logograms. Evidence from the period shows that the knowledge of astronomical observations and calculations was considered highly sensitive and private knowledge,[41] and recording their astronomical information in an obsolete language (in a time when few of the general population could read in any case)[42] would certainly have helped their methods to remain private.

1.3.2 Non-Mathematical Astronomy

1.3.2.1 Goal-Year Astronomy

As we have already seen, "Goal-Year astronomy" is a general term used to encompass the non-mathematical Babylonian texts which use empirical methods of prediction, relying on the periodic motions of the planets and the Moon to predict future events. As a major question of this thesis is how exactly the Babylonian astronomers predicted planetary events using Goal-Year methods, Chapters 4, 5 and 6 are devoted to various aspects of this

discussion by Oppenheim (1969).

[38] Recorded in the Babylonian Astronomical Diary *ADART* Vol. I No. -273B.

[39] McEwan (1981), pp. 15-21.

[40] McEwan (1981), p. 20, from a Babylonian temple document dating to around 100 BC. These texts are also discussed in van der Spek (1985), Pearce & Doty (2000), Rochberg (2004).

[41] Rochberg (2004), pp. 212-219 discusses the common warnings on colophons of Babylonian astrological texts that the information they contain is "secret knowledge" that may only be shown to "another one who knows" (p. 212).

[42] Bertman (2003).

topic. Although both lunar and planetary events are predicted using Goal-Year methods, the planetary predictions have received comparatively little attention from researchers in the past. By contrast, both non-mathematical predictions of lunar events (outlined in the following section), mathematical predictions, and horoscopy (both outlined later in this chapter) have been the subject of extensive research and writing by previous scholars, and so the following chapters need not discuss their uses in detail.

1.3.2.2 Lunar Astronomy

Being aware of the Moon's appearance and disappearance was very important since, as we have seen, the Babylonian calendar was based on the lunar month. To help keep track of the Moon's phases, the Babylonian astronomers recorded the six time intervals described in Table 1.2, on key dates around the full moon and new moon of each month. These six intervals are now generally known as the Lunar Six.[43]

Name (cuneiform transliteration)	When during month	Description
na	New moon	Time interval between sunset and moonset on the first evening the new moon is visible
ŠÚ	Full moon	Time interval between moonset and sunrise the last morning the Moon sets before sunrise
ME	Full moon	Time interval between moonrise and sunset the last evening the Moon rises before sunset
na	Full moon	Time interval between sunrise and moonset the first morning the Moon sets after sunrise
GE_6	Full moon	Time interval between sunset and moonrise the first evening the Moon rises after sunset
KUR	End of the month	Time interval between moonrise and sunrise the last time that the Moon is visible before new moon

Table 1.2: details of the Lunar Six

Some texts instead include the Lunar Three, which are the dates on which the following three events would be observed: *na* at the beginning of the month, *na* in the middle of the month, and KUR at the end of the month. Modern scholars occasionally refer to the Lunar Four, meaning the four Lunar Six events which occur around full moon. In recent times some significant research has been done on the prediction of Lunar Six values, showing that the Babylonian astronomers were able to predict the timings of Lunar Six events using Goal-Year type periodic relations from the 7th century BC.[44]

The other major lunar phenomenon recorded in Babylonian astronomical texts is the eclipse. Eclipse prediction could be considered one of the crowning achievements of Babylonian astronomy; the theory was so well understood that dates of every possible known lunar and solar eclipse could be calculated well in advance – even eclipses which would not have been visible from Babylon.[45] Babylonian eclipse reports vary from very terse (giving just the date and approximate time the eclipse began) to extremely detailed (giving the date, position of the Moon, timing of each phase of the eclipse, measurement of maximal solar/lunar coverage, positions of the planets during the eclipse, and other details[46]).

[43] Following Sachs (1948).
[44] See the work of, for example, Brack-Bernsen (1999a and 1999b), Brack-Bernsen & Hunger (2002), Huber & Steele (2007).
[45] Steele (2000a and b).
[46] Huber & de Meis (2004).

Even though the main focus of this work is on planetary prediction, the connections between planetary and lunar methods of prediction will be considered in subsequent chapters: Chapter 3 includes eclipse predictions in its analysis of the "beginning" and "end" regions of zodiacal signs, and Chapter 6 briefly considers the effect of the Babylonian calendar's intercalary months on the prediction of Lunar Six events.

1.3.3 Mathematical Astronomy

In contrast to the above non-mathematical texts, the mathematical cuneiform texts (mostly published as the *Astronomical Cuneiform Texts* (*ACT*)[47]) are devoted to theoretical schemes of planetary and lunar motion, and calculated predictions of events. The first mathematical astronomical texts date to before the Seleucid Era, and the latest to around SE 350 – a very similar timescale to the dates of extant non-mathematical predictive texts (see Figure 2.1 in the following chapter). *ACT* contains comprehensive descriptions of the texts' contents and the astronomical theories used to compute the data and so a brief outline of their contents and methods will suffice here.

Neugebauer in *ACT* divides the texts into three categories:

- Ephemerides, which list dates and positions of the Sun, Moon or a planet at the time of key events (such as new moon, or a planet's Greek-letter phenomena) over a period of, typically, several years. For lunar ephemerides, other calculated data such as latitude and velocity are also included.

- Auxiliary functions, which contain calculations of one of the (fifteen or more) functions needed to construct the lunar ephemerides.

- Procedure texts, which describe the rules and methods behind calculating the ephemerides. The planetary procedure texts are examined further in Chapter 4, which contains an assessment of the planetary periods referred to in these texts along with the various planetary periods mentioned in the few extant examples of other, non-mathematical procedure texts.

One question that is not answered in the Babylonian texts themselves is the nature of the connection between mathematical and non-mathematical astronomy. This raises several potential issues: for example, were the same observations used for both mathematical and non-mathematical predictions of events? As §1.3.5 on "Terminology" will show, lunar and planetary positions in the non-mathematical texts (both observed and predicted) are generally recorded relative to a nearby star, or by a positional statement involving a zodiacal sign. It is rare to find a planet's position at the time of its first appearance, for example, recorded more precisely than within the 30° region of a zodiacal sign.[48] Yet the mathematical texts calculate positions to an apparently much more precise scale – to within fractions of a degree of a zodiacal sign.

Could the less precise observational records really have been the source of the mathematical ephemerides' calculated values? Neugebauer believed that the non-

[47] Neugebauer (1955).

[48] Some texts specify an event with slightly more precision as occurring the "beginning" or "end" of a zodiacal sign – see Chapter 3 for a discussion of the size of these regions. Such regions are, nevertheless, still many times larger than the apparent precision of the mathematical ephemerides.

mathematical texts would have been "useless" for this purpose,[49] although Aaboe[50] and Swerdlow[51] speculate on ways that it could have been done. As with so many aspects of Babylonian astronomy, there is no direct confirmation from the sources and so one cannot be certain.

Secondly, were the same mathematical procedures used to calculate dates of both the mathematical ephemerides and the Goal-Year type predictions? As stated above, Sachs considered the *ACT* ephemerides to be a potential source of the non-mathematical predictions, and it is clear that some connection exists between the mathematical and non-mathematical texts. For example, Huber has shown[52] that dates when a planet was said to reach the zodiacal sign Gemini, Cancer or Aquarius matches dates predicted for a planet to pass by the Normal Star ζ Tauri, β Geminorum or δ Capricorni respectively.[53] Therefore, the division of the zodiac in the mathematical texts, and the positions of planetary passages from the non-mathematical texts, are at least compatible systems of recording positions.[54] However, in Chapter 2 I show that the planetary ephemerides in *ACT* are extremely unlikely to have been the source of the non-mathematical predictions, so we can be almost certain that the same procedures were *not* used in each case.

Lastly, were the two types of astronomy even carried out by the same people? There is certainly evidence in favour of this situation: firstly, as described above, the mathematical and non-mathematical types of prediction are made using connected, if not identical, methods. Secondly, the existence of temple documents from Babylon, such as the one quoted above in §1.3.1 which concerns the appointment of an astrologer who will "make the observations and give the calculations and measurements".[55] The wording is not conclusive, but certainly suggests one single group of people carrying out both the mathematical and non-mathematical astronomy.

Yet, one could imagine a situation where two groups of astronomers worked completely separately, one group observing and making predictions based on non-mathematical methods, and the other using mathematical methods. Neugebauer,[56] for example, certainly believed that this was the case.

1.3.4 Astrology and horoscopes

As described in §1.3.1, the omen traditions of earlier periods evolved into the personal horoscopes found in the Late Babylonian Period from the 5th to the 1st centuries BC. There has been extensive analysis of Babylonian horoscopes in recent years, particularly by Rochberg,[57] and so I shall not describe their contents in any detail here. Instead I shall just mention one important link between horoscopy and the other strands of Late Babylonian astronomy: the non-mathematical predictive texts known as Almanacs appear to contain all of the necessary information for the compilation of horoscopes, and it could be speculated that they were created for this purpose.[58] (See Chapter 2 for the contents of the Almanacs.)

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[49] Neugebauer (1989), p. 393.
[50] Aaboe (1980).
[51] Swerdlow (1998).
[52] Huber (1958).
[53] See also Chapter 3 for more discussion of this, and Steele & Gray (2007).
[54] See also Steele (2007a).
[55] McEwan (1981).
[56] Neugebauer (1989).
[57] For example, Rochberg-Halton (1989, 1991), Rochberg (1998, 2004); see also Pingree (1998).
[58] Rochberg (2004), pp. 153-157.

1.3.5 Terminology used in Late Babylonian astronomical records

The terminology used to describe astronomical events in the Late Babylonian texts is quite formulaic and terse, and the records have a high logographic content. This means that it can be difficult to determine an exact translation of a record, even while the *concept* which the logogram (or series of logograms) describes can be well understood, due to the periodic and repetitive nature of astronomical records.[59]

This section therefore outlines the important concepts found in the Babylonian astronomical records, which will be referred to in future chapters. The key points which will be described are: i) ii) what reference points the Babylonian astronomers used for recording positions of the planets and Moon; and iii) what units they used to measure distances and times.

1.3.5.1 Planetary names

The planets visible to the naked eye (i.e. Mercury, Venus, Mars, Jupiter and Saturn) are referred to by many different names in the various cuneiform texts.[60] Conveniently, the Late Babylonian astronomical texts with which we are concerned here consistently use only one name for each planet (with a very small number of exceptions). Table 1.3 shows the Akkadian names of the five planets and their possible translations; recall that several alternative translations may be possible due to the many syllabic and logographic interpretations of cuneiform signs. For example, the signs used to denote Mercury could also be read as "the white bull".

Planet	Babylonian name		Meaning
Mercury	GU_4.UD	*Šiḫṭu*	jumping planet
Venus	*dele-bat*		meaning unknown
Mars	AN	to be read *ṣalbatānu*?	meaning unknown
Jupiter	MÚL.BABBAR	BABBAR = *peṣûm*	the white star
Saturn	GENNA = TUR + DIŠ	TUR = *ṣeḫru*?	small

Table 1.3: planetary names from the Late Babylonian astronomical texts

In some of the later Seleucid texts these names may be abbreviated, for example Jupiter may be referred to as BABBAR rather than MÚL.BABBAR.

In the astronomical texts considered in this work, the planets were virtually always considered to follow the conventional sequence of Jupiter, Venus, Mercury, Saturn, Mars. This specific order of the planets is almost invariable in Seleucid Era astronomy and is likely connected with how benefic or malefic each planet's influence was regarded as being.[61]

1.3.5.2 Sidereal motion

The motion of the planets and the Moon with respect to the stars was recorded by the use of reference stars – a number of bright stars close to the ecliptic, known to us now as Normal Stars,[62] were used for this purpose. A typical report of a Normal Star passage

[59] See for example the translators' comments throughout the Introduction in Sachs & Hunger (1988), or the decipherment of the text TU11 by Brack-Bernsen & Hunger (2002).
[60] See for example Brown (2000), pp 53-103.
[61] Rochberg-Halton (1988b).
[62] So called following Epping (1889). For a list of the 32 Normal Stars most commonly used in observations see Sachs & Hunger (1988), pp. 17-19.

records the date on which the Moon or planet passed close to a star, and a measurement of how closely it reached the star. Generally these measurements stated that the planet was a certain distance "above" or "below" the star, with (much less commonly) a second measurement of how far the planet was "back to the west" or had "passed to the east" from the star. An alternative, but much less common way of recording the measurements was to record first a distance that the planet was "behind/in front of" the star, combined with a distance that it was "high to the north" or "low to the south".

There is no Babylonian source to attest exactly what was meant by a planet being "above", "below", "in front of" or "behind" a star. Graßhoff believes that these terms correspond to a difference in latitude (above/below) and a difference in longitude (in front of/behind).[63] Jones suggests that the moment when a planet passed a Normal Star was determined by means of an imagined reference line between the star and a reference point at a similar longitude (perhaps another nearby star) – perhaps using the "string" described below.[64] "Above/below" would then be a distance along this line, and (presumably) "in front of/behind" would be a distance in the direction perpendicular to the line.

The distances are almost always given in terms of the Babylonian units of cubits and fingers, where 1 cubit = 24 fingers. It seems from the mathematical texts that a cubit was intended to be an arc of 2°; evidence from the astronomical texts is that it was in practice around 2.3°.[65]

How might the distance measurements have been made? No astronomical tools remain from the period, nor any texts describing exactly how the apparent distances between celestial objects were measured or estimated. Some texts contain somewhat unclear references to "strings",[66] which allows one to speculate that a string or stick might have provided a visual aid for estimating distances by eye. However, there is no certainty that this was the case.

1.3.5.3 Synodic phenomena

The planets' motion with respect to the Sun was recorded by their synodic phenomena. (As we have already seen, the Moon's synodic motion was recorded by the dates and times of the Lunar Six.) The synodic planetary events which the Babylonian astronomers watched for and predicted are nowadays known collectively as the Greek-letter phenomena.[67] Table 1.4 summarises which events were recorded for the inferior and superior planets, along with the conventional Greek-letter designations.

Superior Planets		Inferior Planets	
Γ	First visibility	Γ	First visibility in the east
Φ	First stationary point	Σ	Last visibility in the east
Θ	Acronychal rising	Ξ	First visibility in the west
Ψ	Second stationary point	Ω	Last visibility in the west
Ω	Last visibility		

Table 1.4: details of the Greek-letter phenomena

[63] Graßhoff (1999).
[64] Jones (2004).
[65] Steele (2003).
[66] For example, Pingree & Walker (1988); Brack-Bernsen & Hunger (2002), p.19.
[67] So called following Sachs (1948) and Neugebauer (1954), who assigned each phenomenon a particular Greek letter in order to be able to refer to them more concisely.

Note that "acronychal rising" has often been assumed to mean the planet's opposition with the Sun. It has now been shown that the moment of acronychal rising was actually more likely to be the point at which the planet rose at sunset – close to the moment of opposition, but not exactly the same. [68]

A typical report of a planet's Greek-letter phenomenon includes the date on which the phenomenon was observed (or expected) and, sometimes, details of the planet's position at the time of the event. The level of detail recorded varies depending on the type of phenomenon. Generally a record of an acronychal rising will give no information at all on the planets' position. Records of first or last visibilities usually state in which zodiacal sign the planet was on that date (i.e. in which region of the ecliptic - see the following section).[69] Observations of stationary points tend to record the planets' position with reference to either its zodiacal sign or its proximity to a Normal Star; Chapter 3 examines some of the differences from this format found in *predictions* of stationary points.

1.3.5.4 Zodiacal signs

The concept of the zodiac, first seen in texts from around the 5th century BC, was an immensely important development in Late Babylonian astronomy. The concept of dividing the ecliptic into 360 equal regions (i.e. 360°) and further into 12 signs each 30° long, greatly improved the ease of calculating celestial positions.[70] Previously, planetary positions at the time of, say, Greek-letter phenomena, would be recorded relative to nearby constellations, which were irregularly-sized and did not cover the entire sky. Compared with this, the concept of a theoretical division of the ecliptic, which did not necessarily relate to anything visible on the sky[71] but provided a sequence of regularly-spaced divisions with no gaps, makes mathematical astronomy much easier to carry out.

Table 1.5 lists the zodiacal signs used by the Babylonian astronomers, showing a transliteration of the Akkadian name and its translation, along with the modern Western name of the corresponding zodiacal sign and its longitude. (Note that the correspondence between regions of the zodiac and specific longitude ranges has altered since Babylonian times due to the precession of the equinoxes, which must be taken into account when calculating longitudes of synodic events.[72]) It is easy to see that many of our modern names for the zodiacal regions have their origin in the Babylonian zodiac. Chapter 3 examines in more detail when and how the Babylonian astronomers used the zodiac.

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[68] Swerdlow (1999), Hollywood & Steele (2004).

[69] Alternatively, an occasional expected appearance or disappearance of Mercury is described as "omitted", rather than any information on its position being recorded. This means that it was not visible from Babylon for the whole of its eastern or western phase; Chapter 7 examines in some detail why and when this was the case.

[70] Brack-Bernsen & Hunger (1999), Steele & Gray (2007).

[71] As described in the section on mathematical astronomy, Huber (1958) shows how the boundaries of some zodiacal signs were designated by particular Normal Stars. However, not all of the zodiacal boundaries have bright objects located conveniently nearby.

[72] Huber (1958), Steele & Gray (2007).

Babylonian name		Modern name	Beginning of zodiacal sign – longitude
ḪUN	Hired Man	Aries	0°
MÚL	Bull	Taurus	30°
MAŠ	Twins	Gemini	60°
KUŠÚ	Crab	Cancer	90°
A	Lion	Leo	120°
$ABSIN_x$	Barleystalk	Virgo	150°
RÍN	Balance	Libra	180°
GÍR.TAB	Scorpion	Scorpio	210°
PA	Pabilsag	Sagittarius	240°
MÁŠ	Goat-Fish	Capricorn	270°
GU	Great One	Aquarius	300°
zib.^{ME}	Tails	Pisces	330°

Table 1.5: the names and longitude ranges of the zodiacal signs used in Babylonian astronomy

1.3.5.5 Time measurements

Now that we have examined measurements of position and distance, let us move onto measurements of time. For non-mathematical planetary events, this is very simple: Normal Star passage records state whether the planet was visible in the early or late part of the night, but (reasonably) do not make any attempt to observe the exact time of a passage. The planets, even Mercury, do not move fast enough that it would make any sense to record the time of a passage with any more accuracy than to within a few hours. For lunar passages by Normal Stars, a similar terminology is found.

The regular Lunar Six measurements record how long the Moon is visible for around sunrise or sunset, and occasionally a similar measurement for a planets' length of visibility is noted around the time of an appearance or disappearance. (This is discussed further in the following chapter.) The time is always recorded using the Babylonian unit of time "*uš*"; *uš* is commonly rendered as "degree" in translation, because there were 360 *uš* in a day. From remarks in Babylonian texts, it seems that these times were probably measured using a waterclock.[73]

Another way of measuring time is found in eclipse observations. The time of a *predicted* eclipse is always given in terms of degrees before/after sunrise or sunset. The same terminology can be found in observational records of eclipses; alternatively, in later observational texts the time an eclipse began was often recorded relative to the culmination of a particular star or group of stars.[74]

Finally, for records of all other periodic events which are found in the observational texts (such as equinoxes, solstices or the appearance of Sirius[75]) only the date of the event would be recorded.

Another method of recording the passage of time is found in the mathematical astronomical texts: rather than having the confusion of whether individual months have 29 or 30 days when calculating dates, a division of time known as a "tithi" is regularly used for

[73] Neugebauer (1947), Stephenson (1974), Hunger & Pingree (1989).

[74] A list of the stars used for this purpose, known as "ziqpu stars", is found in MÚL.APIN (Hunger & Pingree, 1989).

[75] For these particular events the *predicted* date was almost invariably recorded, as shown in the above section on "Calendrical Systems"; see also Chapter 2. For details of records involving the rising and setting of stars other then Sirius, see Chapter 3.

calculations instead.[76] A tithi is defined by dividing the length of the mean synodic month into 30 parts, i.e. 1 tithi = ~29.531 days ÷ 30 = ~0.984 days. Tithi are very useful for simplifying mathematical calculations of dates, though they are not found in the non-mathematical texts.

1.4 Modern calculations of Babylonian astronomical events

As later chapters will show, modern calculations of astronomical ephemerides can be an extremely useful tool with which to compare ancient records. During the course of this study, several computer programs which calculate various astronomical events have been used for this purpose. These programs, along with the assumptions used in the calculations of each one, are outlined below. A computer program can calculate centuries of astronomical events extremely quickly, with no loss of data due to erosion of texts or due to bad weather having prevented observation, and hence can provide large datasets which can be used to aid our understanding of ancient astronomical methods. However, one must exercise caution and question what assumptions have been made during the calculation of these ephemerides.

For example, calculating dates of sidereal events such as Normal Star passages is reasonably straightforward – in effect, one only needs to calculate the planet's daily longitude and latitude, which can then be compared with the known longitudes and latitudes of the Normal Stars at that time. Conversely, calculating the date on which a planet or star is visible for the first or last time depends on what values have been assumed for several variables, such as the quality of atmospheric viewing conditions at the horizon, or the distance below the horizon the Sun must be for a particular planet to be visible. Obviously, it is impossible to find a method of calculation which would perfectly replicate the recorded Babylonian dates of planetary phenomena, because the day-to-day observing conditions could never be reproduced exactly. Therefore, one must not use these computer programs expecting exact Babylonian dates of phenomena but rather *approximate* dates on which the phenomena could have been viewed in Babylon, perhaps assuming slightly better viewing conditions than were available at the time.

In general, one needs to be able to account for:

i) The methods used to assess a star or planet's visibility (if a program calculates dates of phenomena), particularly around its appearance or disappearance. The dates do not need to match the Babylonian records exactly, but one needs to show that they consistently approximate the Babylonian records of dates;
ii) Whether calculated longitudes are tropical, or whether they have been altered to account for the precession of the equinoxes;
iii) What values have been used when accounting for the long-term changes in the Earth's rotation speed. A recent estimation of the parameters suggests that during the centuries spanned by the Late Babylonian Period, ΔT varies between approximately 10,000 – 15,000s ≈ 3 to 4 hours.[77] As we have already seen, the planetary events which are investigated in this study are not generally recorded with a precise time, only to within a day. In practice, this means that it will rarely make a difference to the computed dates of Babylonian planetary events whether they are calculated using Universal Time (UT) or Terrestrial Time (TT). However, it will still be useful, if possible, to determine what values the programmers have used.

[76] The name "tithi" is the word used for the same concept in Indian astronomy.
[77] Stephenson (1997).

1.4.1 The "Horizons" ephemeris

This tool from Caltech's Jet Propulsions Laboratory provides highly accurate ephemerides for solar system objects, using values for the orbital parameters which are as precise as statistically possible.[78] In terms of the present study, this means it provides a useful source of planetary tropical longitudes and latitudes relative to an observer in Babylon.

When calculating dates and times, the formula this tool uses for ΔT is:

$$\Delta T = 31\ T^2$$

where T is the number of centuries since 1820. This suggests that dates within the Late Babylonian Period will have a value for ΔT of around 10,000 to 19,000s – a fine approximation.

1.4.2 The "Bretagnon" ephemeris

A computer program has been developed by F. R. Stephenson and K. K. C. Yau which calculates positions of the planets and the sun relative to an observer in Babylon, based upon the Bretagnon ephemeris.[79] Bretagnon et al thoroughly discuss the accuracy of the solar and planetary tables in their paper, and the authors also explain why they have *not* taken ΔT into account at all, instead choosing to express their tables in terms of Ephemeris Time.[80]

In practice this means that the "Bretagnon" computer program calculates tropical longitudes and latitudes which agree extremely well with those calculated by the "Horizons" ephemeris, but offset by some 3 to 4 hours due to the application of ΔT.

1.4.3 N. A. Roughton's planetary tables

Roughton has made available his planetary tables, which show calculated dates of ephemerides associated with Normal Star passages and Greek-letter phenomena for the planets across a period of several hundred years between 602 BC and 76 AD. The criteria employed to determine event dates are described in his explanatory paper, and some of the calculated results are compared with records of Babylonian dates.[81]

In general, the dates in Roughton's tables are a very good approximation of Babylonian dates of events. However, it must be noted that the tables show a particular lack of agreement with the Babylonian records of the date on which a planet becomes stationary. Roughton explains that the calculated dates of stations are those where the planet reaches a maximum or minimum in longitude to 3 decimal places, a level of precision which is clearly impossible to determine by eye. This difficulty with observing a planet's true station will be discussed further in Chapter 4.

It must also be noted that Roughton's tables differ from the Babylonian texts in that they omit entirely the eastern or western phases where Mercury never meets the criteria for visibility. As we have seen, in the Babylonian texts dates of these missing appearances and disappearances are noted with the terminology "omitted"; this will be discussed further in

[78] The "Horizons" tool, and its full documentation, can be found online at http://ssd.jpl.nasa.gov/horizons.cgi .
[79] Bretagnon et al (1985), with thanks to F. R. Stephenson for making his FORTRAN program available.
[80] Bretagnon et al (1985), pp. 42-43.
[81] Roughton (2002), with thanks to N. A. Roughton for making his databases of planetary events available.

Roughton's paper makes no mention of ΔT. The calculated dates are recorded in the form of a Julian day number, suggesting that no TT-UT correction has been applied.

1.4.4 The "Alcyone" ephemeris

The "Planetary, Lunar and Stellar Visibility" function of this ephemeris can be used to calculate the rising and setting times of the sun, Moon, a planet, or a star from any location on earth.[82] For the present study, this means that the software can usefully be used to determine dates on which a star or planet might have been visible from Babylon.

A brief investigation demonstrates that the criteria assumed by the software for an object's visibility from Babylon do not match exactly with dates in the Babylonian texts, as expected. For example, around 100 BC the ideal scheme used during the Seleucid Era to calculate Sirius' yearly phenomena corresponded to the following dates in the Julian calendar:[83]
Last appearance - ~14th May
First appearance - ~18th July
Acronychal rising - ~1st January.

The Alcyone software returns these dates for the same phenomena:
Last appearance - ~11th May
First appearance - ~20th July
Acronychal rising - ~27th December.

In other words, the software can provide a good general tool for understanding when a planet or star may be visible from Babylon or not, but it should not be used for determining exact dates of phenomena.

The documentation for the Alcyone software compares eight different models for ΔT. Unfortunately the documentation does not directly state (at the time of writing) which of these models they follow in their ephemerides calculations.

[82] The "Alcyone" software, and its full documentation, can be found online at http://alcyone.de/ .
[83] The dates of the scheme are summarised in Hunger & Pingree (1999), p. 153.

Chapter 2

The non-mathematical astronomical texts

Let us now move on to examining in detail the various text types used in Goal-Year astronomy. Over 60 years ago, Abraham Sachs classified the non-mathematical astronomical texts into four categories: the Astronomical Diaries, Goal-Year Texts, Normal Star Almanacs and the Almanacs.[84] Despite working from only a handful of texts, his classifications have proved remarkably robust and are still applicable today to the many non-mathematical tablets which have been identified since then. To these four categories we add a fifth, more general category to cover other lunar and planetary texts.

This chapter will describe the contents of the various types of texts, and examine how the records in them are connected. As stated in the previous chapter, when making reference to a particular text which has been translated by Sachs & Hunger[85] I refer to as *ADART* Vol. m No. n. This chapter also deals with texts which have not yet been published in translation, and when this is the case I will refer to a text as *LBAT nn*[86] or its museum number as appropriate.[87]

2.1 The Astronomical Diaries

The basic observational texts of the period are known as Astronomical Diaries, which contain nightly records of a varied collection of astronomical events. The earliest extant Diary covers the year -651 and the latest one covers the year -60, so the Diaries were evidently produced across the entire Late Babylonian Period (in accordance with Ptolemy's statement that he had complete records dating back to the reign of Nabonassar).[88] However, unlike the records available to Ptolemy, our archive of Diaries is much smaller; particularly for the pre-Seleucid centuries. We have only one extant Diary from each of the 7th and 6th centuries BC, and only two from the 5th century BC. Inevitably some tablets have gone missing or sustained damage over the intervening 2000 years; Figure 2.1 later in this chapter shows for which years Diaries have survived to the modern day.

A typical Astronomical Diary covers 6 or 7 months[89] and records, on a nightly basis, astronomical events including:

Passages of the Moon and the planets by Normal Stars,
The planets' Greek-letter phenomena and the Lunar Six,
Observed eclipses, or dates of eclipse possibilities,
Dates of solstices, equinoxes, and the star Sirius' Greek-letter phenomena,

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[84] The text types are classified according to Sachs (1948).

[85] All known and dated Diaries have been published in Sachs & Hunger (1988, 1989, 1996), except for a very few which have been dated since; translations of all known Goal-Year Texts have been published in Hunger (2006); translations of all known non-mathematical lunar and planetary texts have been published in Hunger (2001), except for some which were instead published in Hunger (2006): *ADART* Vol. VI Nos. 19, 24.

[86] Sachs (1955), *Late Babylonian Astronomical and Related Texts* (hereon abbreviated to LBAT). In keeping with Sach's terminology, an LBAT number with no asterisks means that a copy of the text was included in LBAT; an LBAT number with one asterisk means that the text was not copied into LBAT and that it had not been published elsewhere (as of 1955); an LBAT number with two asterisks means that a copy or a translation of the text had already been published before LBAT.

[87] Many copies of other Babylonian astronomical texts can be found in Epping's *Astronomische aus Babylon* (1889), and parts I and II of Kugler's *Sternkunde und Sterndienst in Babel* (1907 and 1924); (hereafter abbreviated to AAB, SSB I and SSB II respectively), also Kugler & Schaumberger (1935).

[88] As discussed in the previous chapter, and in Sachs (1974).

[89] Although shorter Diaries covering fewer months, or only a few days, are not uncommon – see Hunger & Pingree (1999), pp 142-4.

Other, less common, astronomical events such as comets,
The weather, particularly when it was bad enough to prevent observing, or in the case of an ominous event such as a rainbow.

At the beginning of each month is a statement of whether the previous month had 29 or 30 days, and at the end of each month is a summary of the planets' positions during the month[90] and a section summarising non-astronomical events. In later Diaries (infrequently from -453 onwards, and regularly from -266) the planetary summary would also contain the dates of planets' first and last appearances (and, very occasionally, other Greek-letter phenomena). From -212 onwards the summaries also generally contained the dates on which a planet moved to the next zodiacal sign – see Chapter 3 for more discussion of this development.

In the non-astronomical section would typically be found prices of staple goods in Babylon's market during the month,[91] measurements of the river level and how it changed during the month; and a report of news which had reached the Diary compilers' attention, either events occurring in the city of Babylon or news from elsewhere. Earlier Diaries also occasionally record events which could be seen as ominous such as the hatching of a three-footed bird.[92]

2.1.1 The effect of bad weather on the Astronomical Diaries' records

It is important to note that although the Diaries are primarily observational texts, from the very earliest texts they also contain calculated dates and measurements. In particular, Lunar Six measurements and dates of events are found to be estimated at times when the weather is too bad for observation; and dates of solstices, equinoxes and Sirius phenomena were nearly always calculated according to a 19-year scheme from the 4th century BC onwards.[93] Similarly, the dates of possible eclipses were calculated according to a scheme throughout the entire period and, while some Diaries contain extremely detailed reports of eclipse observations, dates of eclipses which would not have been visible from Babylon were, of course, always calculations rather than observations.[94]

Compensating for observations which were missed due to bad weather is a feature of all of the Astronomical Diaries. That an event was estimated or calculated rather than observed is noted by the logograms NU PAP, translated by Sachs & Hunger as "I did not watch", and often accompanied by a remark on the weather. For example:

> GU_4-UD *ina* NIM *ár* $^{mul x}$KUN^{me} ŠÚ(!) *ù* SAG-UŠ *ár* $^{mul x}$KUN^{me} ŠÚ U_4^{me} ŠÚ^{me} NU PAP
> "Mercury's last appearance in the east behind Pisces, and Saturn's last appearance behind Pisces; I did not watch because the days were overcast."
> (*ADART* Vol. I No. -651, col. i 7-8)

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[90] This is standard by the date of the 3rd oldest Diary, *ADART* Vol. I No. -463, onwards. The 2nd oldest Diary, *ADART* Vol. I No. -567, appears to have a planetary positions summary at the *beginning* of the month. These early texts summarise planetary positions with respect to nearby constellations; later texts instead summarise planetary positions within zodiacal signs. (Again, with such sparse records for the early part of the period it is extremely difficult to narrow down the dates of astronomical developments.)
[91] The market prices and fluctuations have been analysed by Slotsky (1997).
[92] *ADART* Vol. I No. -418. Ominous births and weather events are significantly more common in the earlier Diaries, becoming less common as the importance of *Enūma Anu Enlil* omen interpretation waned.
[93] Neugebauer (1948), Sachs (1952b).
[94] Steele (2000a).

	Text no.		Year (SE)	Date	
Diary	-182 A	Obv. 13	129	23	Mercury's last appearance in the west in Gemini; clouds; I did not watch
Alm	LBAT 1123	Obv. 5	129	21	Mercury's last appearance in the west in Gemini
Diary	-178 A	Obv. 9	133	[10]	Mercury's last appearance in the [east] in Leo; I did not watch; the north wind blew
NSA	MLC 1885	Obv. 9	133	10	Mercury's [last] appearance in the east in Leo
Diary	-132 D_1	Rev. 21	179	14	Mars' last appearance in Aries; clouds; I did not watch
Alm	LBAT 1135	Rev. 5	179	14	Mars' last appearance in Aries
Diary	-122 A	Obv. 10	189	Around the 4	Mercury's last appearance in the west in Taurus; clouds; I did not watch
NSA	LBAT **1055	Obv. 8	189	4	Mercury's last appearance in the west in Taurus
Diary	-77 B	Obv. 14	234	Around the 8	Mars' acronychal rising; I did not watch
Alm	LBAT 1164-5	Rev. 1	234	8	Mars' acronychal rising
Diary	-77 B	Rev. 10	234	Around the 28	Mercury's last appearance in the east in Aquarius; clouds; I did not watch
NSA	BM 32247	Rev. 15	234	28	Mercury's last appearance in the east in Aquarius
GYT	37	Obv. 7	96	13	Mercury's last appearance in the west in Gemini; I did not watch
NSA	LBAT **1007	Obv. 6	96	13	Mercury's last appearance in the west in Gemini
GYT	37	Obv. 11	96	21?	Mercury's first appearance in the east in Capricorn; I did not watch
NSA	LBAT 1008	Rev. 14-15	96	21	Mercury's first appearance in the east in Capricorn
GYT	92	Obv. 13	201	Around the 11	Mercury's last appearance in the west in Gemini; I did not watch
NSA	LBAT **1059	Obv. 10	201	11	Mercury's last appearance in the west in Gemini

Table 2.1: a comparison of dates of events in the Astronomical Diaries, described as having not been observed, with the predicted date of the same event in the Almanac or Normal Star Almanac for the same year. In 8 out of the 9 cases the dates are the same, suggesting that when the weather was bad enough to prevent observing, event dates in the Astronomical Diaries were supplied from the predictive texts.

In many cases where the weather prevented observation of a planetary event an estimate of the event's date is made, with the record including the Akkadian word *in*, translated by Sachs & Hunger as "around the", date. However, there are also several examples of records where the NU PAP terminology is used and yet an exact date is given for the event. This suggests that, unlike the "around the" terminology which could just refer to a rough estimate, in these cases the exact date was calculated in some way. How might this have been done?

Unfortunately, the small amount of extant data, particularly for the early part of the period, does not allow us to be sure how dates were estimated or calculated. One possibility is via interpolation, for example estimating the date of a planetary phenomenon based on the date of the immediately previous or following phenomenon. This method would have strong links with the *ACT* methods for calculating dates of successive phenomena, particularly the dates of Mercury's "omitted" phases – see Chapter 7 for discussion of these issues.

In the later part of the period, a simpler method to determine dates of events missed due to bad weather would have been to copy event dates from the non-mathematical predictions in the Normal Star Almanacs and the Almanacs (described in the following sections). If this were the case then one would find that the recorded date of a phenomenon described as "NU PAP" in a Diary (or Diary excerpt text such as a Goal-Year Text – described in §2.2) would agree with the *predicted* date of the same phenomenon in an Almanac or Normal Star Almanac for the same year. Table 2.1 summarises the pairs of records which fulfil these criteria.

The lack of overlap between the extant various types of text (see Figure 2.1 later in the chapter) means that there are unfortunately few remaining records which can be compared in this way. Only nine examples remain where a Diary describes a phenomenon as unobserved and a predictive text still exists for the same year to provide the date of the same event. However, of these nine examples, eight of the record pairs available for comparison agree in date. Therefore, it is possible to conclude that during times of bad weather which prevented observing, dates of events were likely to have been filled in from the predictive texts.

2.1.2 The use of "ideal" phenomenon dates in the Astronomical Diaries

A particular terminology is frequently found in Diaries where the first sighting of a planet was judged to be some days later than its *true* first appearance should have been, due to, say, bad weather. A typical example is given here:

> 18 *dele-bat ina* NIM *ina* TIL MÚL-MÚL IGI KUR NIM-*a* 9,30 *na-su in* 16 IGI
> "The 18th, Venus' first appearance in the east in the end of Taurus; it was bright (and) high, rising of Venus to sunrise: 9°30; (ideal) first appearance on the 16th"
> (*ADART* Vol. II No. -167A, Obv. 8 to Rev. 2)

A concept is introduced here which was translated by Sachs & Hunger as the "ideal" date of an observation. In essence, this is simply an estimated correction to the date of events. We can interpret the above example as the Babylonian astronomers stating that they first viewed Venus on the 18th of the month, but that due to its distance from the Sun on that day (i.e. the length of time it took to rise after sunrise), it should actually have been visible two days

earlier.

The equivalent case is also found for last appearances: a date on which the planet was "last seen", and then an expected "last appearance" estimated for some days later. Presumably the measured time difference allowed the astronomers to estimate the required number of days' correction, but we do not yet understand exactly how this was achieved.[95]

The ideal dates of events can often be found in the Diaries' end of month planetary summaries. Planetary summaries may include the observed or the ideal phenomenon date, or another date entirely; it may record only the date or additionally use the "around the" date terminology as described in §2.1.1. To help understand how these various practices changed over time, Appendix A contains details of the Astronomical Diaries' planetary summary contents, to show how often the planetary summaries used the observed or ideal date of an event. The Appendix only includes years for which extant end-of-month summaries, including at least one date of a planetary event, remain. Few useful conclusions can be drawn from Diaries which do *not* fulfil these criteria, which is why they do not appear in the Appendix. That is, it can be difficult to distinguish whether a planetary summary that appears not to contain dates of planetary events does so because it was the scribe's practice not to summarise the dates, or because no planetary events worth summarising occurred during that month, or because the summary may have contained dates at one point but is now broken.

Despite these concerns, it is clear that very few of the pre-Seleucid Diaries include event dates in the planetary summaries, compared with later Diaries. The inclusion of dates seems to have become a standard practice during the early Seleucid Era. The earlier summaries also include only the observed date of an event, even if an ideal date was also recorded; the earliest Diary in which a planetary summary definitely recorded an ideal event date (as far as can be judged from the unbroken records) is from -284. From -260 onwards the planetary summaries always include the ideal date if one was recorded, except for an anomalous summary in -197 which records neither the observed nor the ideal date but a different date again.

The later planetary summaries also tend to record dates of events as "around the" date, even when an exact date is recorded in a text. This terminology is not found in extant planetary summaries from before -286. Another interesting trend is noticeable between -193 and -183: planetary summaries from this date can repeat the entire event record from the text, including both the observed and ideal dates, timing measurements between the planet's visibility and sunrise/sunset, etc. Only in this 10-year period are such detailed reports of events found within the planetary summaries.

Table 2.2 summarises the records in the Appendix, by showing how many months record the ideal date or the observed date of an event. There are four main categories:

i. Text does not include ideal date – summary records observed date
ii. Text includes ideal date – summary records observed date
iii. Text includes ideal date – summary records ideal date
iv. Text is broken – summary records a date which could be observed or ideal

In addition, a few anomalous records do not fit into any of these categories, as described above. Category iv, despite being the most unhelpful, is also unfortunately the most common. It is necessary to stress that one must be wary of drawing absolute conclusions

[95] See the work of, for example, Hunger (1988), Swerdlow (1998), Hollywood (2002).

from a dataset which includes only 182 records spanning 400 years. This is particularly relevant when nearly half the planetary summaries which include the date of an event are from a broken text, such that we cannot be clear whether the planetary summary is repeating the ideal or observed date.

Contents of planetary summary	Number of records	Percentage of records
Text does not include ideal date - summary includes observed event date or "around the" observed event date only	62	34.07%
Text includes observed and ideal event date - summary includes observed event date only	4	2.20%
Text includes observed and ideal event date - summary includes ideal date or "around the" ideal date only	32	17.58%
Summary includes a date or "around" a date but textual record is broken, so the summary date could be either observed or ideal	78	42.86%
Summary includes both observed and ideal event dates	5	2.75%
Summary includes a date which is neither observed nor ideal	1	0.55%
Total	182	

Table 2.2: dates of Greek-letter phenomena in the Diaries' planetary summaries, showing whether they include the observed date or the ideal date from the text. Apart from a few anomalous cases, and the unfortunately many records where the text of the observation is broken, the clear trend is for the planetary summary to include the ideal date when one was recorded, and the observational date when an ideal date was not recorded.

Of the other categories, i and iii are common and ii is particularly uncommon (and only found in the earlier texts). Three conclusions can be drawn from this. Firstly, more often than not, records of phenomena do *not* include an ideal date. In such cases the planetary summary will obviously copy the observed date of the event. Secondly, if a record of a phenomenon includes an ideal date, the planetary summary will almost invariably copy the ideal date in preference to the observed date. Thirdly, the planetary summaries give no indication of whether the copied dates are ideal or observed. These can only be distinguished by referring to the monthly text of a Diary – which is frequently broken, as we have seen.

Based on this it is important to bear in mind that texts which are made up of Diary excerpts (i.e. texts in *ADART* Vols. V and VI – see §2.2 and §2.5) can include dates which are either the actual date of an observation, or the expected ideal date – and it is not always clear which is true of any particular record. Huber's analysis of the same problem also reached the conclusion that the Diaries' planetary summaries tend to contain what he calls the "inner" observations, i.e. the ideal date of an event.[96]

2.1.3 Duplicate records in the Astronomical Diaries

On occasion, more than one Astronomical Diary exists for the same Babylonian year. This is quite reasonable – as we have established, Diaries typically cover half a year so two are needed for a full year. However, it is interesting to examine the cases where two or more Diaries cover an overlapping time period[97] - in some cases, up to 4 texts exist for the same

[96] Huber (1982), p. 12. See also Huber (1977).
[97] Hunger & Pingree (1999), p. 143 list all years for which overlapping Diaries exist.

month.[98] Often such texts are exact duplicates, but there are several cases where details differ between the two texts. Tables 2.3, 2.4 and 2.5 summarise the ways in which parallel records can differ: Table 2.3 contains all the records which differ on the measured distance of a Normal Star passage, Table 2.4 contains all the records which differ on the timing of a Lunar Six measurement, and Table 2.5 contains all the records which differ on the date of a planetary event.

The record comparisons all come from different Diaries for the same year or from the Lunar texts collected in *ADART Vol. V* (described in §2.5), which contain excerpts from the Diaries. Some of the differences in these tables are undoubtedly copying errors rather than disagreements; the cuneiform system of numbers means that confusing 1 and 4, or 4 and 7, can be quite easy to do. Nevertheless, the tables demonstrate that there could be substantial divergence in records of the same astronomical event, and this is strong evidence that multiple people were involved in observing and compiling the Diaries. Table 2.3 shows that estimations of a planet-star distance regularly differed by as much as half a cubit. On the other hand, Table 2.5 shows that discrepancies in the recorded dates of events were extremely uncommon. Only seven date differences were found in parallel Diaries, of which 4 come from the same pair of texts. Disagreements regarding the date of a planetary event should therefore be regarded as an extremely unusual event.

	Text No.	Measurement 1	Text No.	Measurement 2
Moon	-191A, 27'	1 ½ cubits	-191B, Obv. 2	2 ½ cubits
	-178C, Obv.' 7	4 cubits	-178D, Obv.' 8	5 cubits
	-132B Obv. 31	2 cubits	-132C Obv. 4	3 ½ cubits
	-132B Rev. 6	1 ½ cubits	-132C Obv. 12	2 cubits
	-132B Rev. 6	1 ½ cubits	-132C Obv. 13	2 cubits
	-132B Rev. 9	2 cubits 6 fingers	-132C Obv. 16	1 ½ cubits
	-119B$_1$, Rev.' 2'	2 2/3 cubits	-119C, 'Obv. 20'	2 5/6 cubits
	-119B$_1$, Rev.' 3'	2[?] cubits	-119C, 'Obv. 21'	1 ½ cubits
	-105A, 'Obv.' 21'	3 cubits	-105B, 'Obv.' 20'	2 ½ cubits
	-105A, 'Obv.' 25'	½ cubit	-105B, 'Obv.' 23'	2/3 cubit
	-105A, 'Obv.' 28'	3 ½ cubits	-105B, 'Obv.' 25'	4 cubits
	-105A, 'Obv.' 33'	1 cubit	-105B, 'Obv.' 31'	1 cubit 6 fingers
	-105A, 'Obv.' 41'	2 ½ cubits	-105B, 'Obv.' 38'	2 cubits
Mercury	-384, 'Obv.' 10	2 cubits 4 fingers	Vol V No. 58, 'Rev. IV 21'-22'	2 cubits 8 fingers
	-255A, Obv.' 17	1 ½[sic] cubits	Vol V No. 73, Rev. III 17	4 ½ cubits
	-209C, 'Obv. 10'	1[?] cubit 8[?] fingers	-209D, 'Obv. 10'	1 ½[?] cubits
Venus	-209C, 'Obv. 3'	1 cubit	-209D, 'Obv. 5'	1 cubit 4 fingers
	-132B Rev. 3	½ cubit	-132C Obv 10	2/3 cubit
	-132B Rev. 13	1 ½ cubits	-132C Obv 21	1 cubit
	-105A, 'Obv.' 26'	3 cubits	-105B, 'Obv.' 24'	3 ½ cubits
Jupiter	-168B, 'Obv.' 9'	8 fingers	-168D, LE 2	6 fingers

Table 2.3: details of records where Diary observations report different distance measurements for the same event, taken from either the Astronomical Diary translations in ADART Vols I-III, or the Diary excerpts in ADART Vol. V.

[98] *ADART* Vol. II No. -168A-D.

Text No.		Month	Phenomenon	Measurement
Diary No. -321	'Rev. 19'	VI	GE_6	7°
Vol V No. 36	'Obv. II 21'			4°
Diary No. -240	'Obv. 13'	IX	GE_6	11° 50'
Vol V No. 40	'Rev.' II 4'			11° 40'
Diary No. -187A	Obv.' 6	VII	ŠÚ	15° 40'
Vol V No. 42	Obv. IV 2			15°? 30'
Diary No. -187A	Obv.' 7	VII	*na*	4° 10+[x'…]
Vol V No. 42	Obv. IV 3			2° 50
Diary No. -187B	'Obv. 3'	XI	ME	7° 30'
Vol V No. 42	Rev. VI 2			6° 40'
Diary No. -187B	'Obv. 4'	XI	ŠÚ	1° 30'
Vol V No. 42	Rev. VI 3			1°
Diary No. -187B	'Obv. 4'	XI	GE_6	6° 30'
Vol V No. 42	Rev. VI 4			6° 20'
Diary No. -187A	'Rev. 24'	XII	ME	2°
Vol V No. 42	Rev. VI 9			1° 40'
Diary No. -187A	'Rev. 24'	XII	GE_6	11°
Vol V No. 42	Rev. VI 8			13° 50'

Table 2.4: details of records where Diaries report different Lunar 6 measurements for the same event taken from either the Astronomical Diary translations in ADART Vols I-III, or the Diary excerpts in ADART Vol. V.

Text no.		Date	Event
-209 C	'Obv. 4'-5'	Night of the 9th […]	Mercury was 1 5/6 cubits above η Geminorum
-209 D	'Obv. 6'	[Night of the 10th]	Mercury was […] above [η Geminorum …]
-209 C	'Obv. 10'	[Night of the 14th]	Mercury 1? cubit 8? fingers above γ Geminorum
-209 D	'Obv. 10'	Night of the 16th	Mercury was 1 ½? cubits above γ Geminorum
-209 C	Rev.' 1	[Night of the 22nd]	[Ve]nus was 2 1/2 cubits below β Geminorum
-209 D	'Obv. 12'	Night of the 23rd?	Venus was 2 1/2 cubits below β Geminorum
-209 C	Rev.' 2	On the 22nd	Saturn's first appearance in the beginning of Taurus
-209 D	'Obv. 13'	Night of the 23rd?	[… Saturn's first appearance in Taurus …] (ideal) first appearance on the 22nd
-143 A	'Flake' 29'-30'	Night of the 17th	[Saturn was] 1/2 cubit [above ϱ Leoni]s
-143 B	'Obv. 5'	[Night of the 18th …]	Saturn was […] above [ϱ Leonis …]
-119 A_2	Obv.' 13'	Around the 26th[sic]	Venus' [first appearance] in the east [in Taurus]
-119 B_1	'Obv.' 9'	Around the 25th	Venus' first appearance in the east in Taurus
-105 A	'Obv.' 35'	Around the 6th	Mercury's last appearance in the west in Cancer
-105 A	'Obv.' 45'	On the 5th	Mercury's last appearance in the west in Cancer
-105 B	'Obv.' 32'	Around the 5th	Mercury's last appearance in the west in Cancer

Table 2.5: details of records where Diaries report different dates for the same planetary event.

2.2 The Goal-Year Texts

Goal-Year Texts are a compilation of planetary and lunar records taken from particular years,[99] which use the periodic motions of the planets to make rough predictions of the events for a particular year (the "goal year"). A typical Goal-Year Text has 8 sections, with each section devoted solely to records involving a particular planet (or the Moon) from a specific year. As discussed in the previous chapter, the planetary sections are always presented in the conventional order: Jupiter's phenomena, Jupiter's passages, Venus, Mercury, Saturn, Mars' phenomena, Mars' passages; the lunar section may come before or after the planetary section.

Table 2.6 shows which periods were used for each type of event. For Jupiter and Mars, a different period was used for Greek-letter phenomena and Normal Star passages. For all the other planets, the same period was used for both types of event.

So a Goal-Year Text predicting goal year Y will have a section containing Jupiter records from the year Y-71, followed by a section containing Jupiter records from the year Y-83, a section containing Venus records from the year Y-8, and so on. All in all it would have been necessary to consult Diaries from at least nine different years in the compilation of each Goal-Year Text.[100]

Planet	Observation type	Period in Babylonian years
Mercury		46
Venus		8
Mars	Greek-letter phenomena	79
Mars	Planetary passages	47
Jupiter	Greek-letter phenomena	71
Jupiter	Planetary passages	83
Saturn		59
Lunar Six and eclipses		18
Sums of Lunar Four		18 ½

Table 2.6: The Goal-Year periods, used in the Goal-Year Texts

2.3 The Normal Star Almanacs

The Normal Star Almanacs are a type of predictive text which was used during the Seleucid Era; the earliest available Normal Star Almanac is dated to year SE 19 (293-292 B.C.) and the latest to year SE 234 (78-77 B.C.). A Normal Star Almanac typically contains predictions of:

> Dates and distance measurements of the planets' passages by Normal Stars,
> Dates and (usually) zodiacal signs of the planets' Greek-letter phenomena,
> Dates and timings of the Lunar Six, or occasionally the Lunar Three,
> Dates and timings of eclipses, or eclipse possibilities,
> Dates of solstices, equinoxes, and Sirius' Greek-letter phenomena,
> In rare cases a Normal Star Almanac also contains dates on which a planet reaches a new zodiacal sign.

[99] Commonly assumed to be excerpts from particular Astronomical Diaries – see "The source of the Goal-Year Texts' records" later in this chapter.

[100] Some Goal-Year Texts also include records from a month or two before or after the observations year. For example, there would be Venus records from year Y-8, and possibly records from the end of year Y-9, or the beginning of year Y-7. This is discussed in detail in Chapter 6.

Note that these are all events of a periodic nature, each of which is also recorded in the Diaries and related texts. As described in Chapter 1, this has led to the suggestion that the Normal Star Almanacs' predictions were derived from observations in the Diaries; this will be examined in more detail later in this chapter, and in Chapter 5.

Unlike the Astronomical Diaries and the Goal-Year Texts, there has been as yet no exhaustive collection and translation of the Normal Star Almanacs.[101] Table 2.7 is a record of the Normal Star Almanacs which were consulted during this research. Where the text was not simply translated from a copy in LBAT, the table shows whether the text had been previously translated, or whether I have translated it from somebody else's copy or from viewing the tablet itself.

Year (SE)	Museum number	LBAT number	Other notes
19	BM 48104		transliterated by John Steele
31	BM 47724	*995	transliterated by John Steele
40	BM 32321+		text viewed in person
51?	BM 34900+	996	text viewed in person
55	BM 32847+	*997, 998	text viewed in person
58	BM 47816	*999	text viewed in person
60	BM 33989	1000	
68	BM 42076	1001	
	BM 40626		text viewed in person
70	MM 86.11.369	*1001a	Transliteration and translation by Walker (2005)
80	BM 42135	1002	
82	Rm 731+	*1003	text viewed in person
	MLC 1860	*1004	transliterated by John Steele
92	BM 41880	1005	
93	BM 41634+	1006	
96	Columbia University Library 6x	**1007	Copy in Goetze (1947)
	BM 41588+	1008	
	BM 47869		
99	CBS 499		transliterated by John Steele
101	Rm 755	*1009	

[101] Full editions of the Normal Star Almanacs are in preparation by Hunger as *ADART* Vol. VII.

Year (SE)	Museum number	LBAT number	Other notes
	BM 32522	*1009a	
	BCMA 1846-1982		transliterated by John Steele
104	BM 34080	1010	
105	BM 40625	*1011	text viewed in person
	BM 41545+, 132283	1012	
106	BM 41022+	*1013-4	transliterated by John Steele
	BM 41846	1015	
107	BM 41520+	1016-8	
108	BM 33987	1019	
109	BM 41117		text viewed in person
111	BM 45696	1020	Copy also in SSB II
113	BM 47909		text viewed in person
116	BM 35542+	1021, 1087, 1090	
120	BM 41599	1022	Copy also in SSB I
121	BM 33450	*1023	text viewed in person
125	BM 35817	1024	
128	BM 47738	*1024a	transliterated by John Steele
133	MLC 1885	*1025	transliterated by John Steele
135	BM 34228	1026	
137	BM 35581+	1027-8, 1091-2, 1094, 1101	
142	BM 41106	*1028a	text viewed in person
146	BM 34116+	1029-30	
150	Ist. U. 193a+	*1030a	transliterated by Hermann Hunger
151	Ist. U. 194	*1031	
156	AO 8530	*1032	transliterated by Hermann Hunger
157	BM 46210	*1033	text viewed in person
157-8	BM 34888+	1034-5, *1036, 1037, 1093	text viewed in person
159	BM 32088		text viewed in person
172	BM 34076+	1038	Copy also in SSB II

Year (SE)	Museum number	LBAT number	Other notes
173	BM 34199	1039	
175	BM 32769+	*1040, 1041-2	transliterated by John Steele
177	BM 35090	1076	
178	BM 33482+	*1042a-c	text viewed in person
179	BM 34056+	1043-4	
183	BM 33448+	*1045-6+1138	text viewed in person
184	BM 34054	1047	
	BM 34620	1048	
187	BM 34868+	1049-50	
	BM 35372	1082	
188	BM 34078	1051	
	BM 34588	1052	
	BM 34395	1053	
	BM 35623+	*1054+1097	transliterated by John Steele
189	BM 34033	**1055	Copy in AAB
190	BM 48072		text viewed in person
192	BM 35637+	1056	
194	BM 34758	1057	
195	BM 34229	1058	
201	BM 34032	**1059	Copy in AAB
203	BM 35340	1060	
203?	BM 37493		
208	BM 32230		transliterated by John Steele
210	BM 34607	1061	
212	BM 35059+	1062-5	
234	BM 32247		Transliteration and translation by Roughton (2002)

Table 2.7: Provenance of the extant Normal Star Almanacs, showing whether they are copied in LBAT or elsewhere.

2.4 The Almanacs

Another type of predictive text in use during the Seleucid Era was the Almanac. The earliest Almanac has been dated to SE 92 (220-219 B.C.) and the latest to SE 385 (AD 74-75) and, as with the Normal Star Almanacs, all the types of events predicted in the Almanacs could have been derived from the Diaries. However, it is an interesting artefact of the texts which have survived to our time that none of the remaining Diaries could have been used in predicting the records in the latest dated Almanacs.[102]

An Almanac's contents typically include:

> The planets' zodiacal signs at the start of each month, and dates on which a planet reaches a new zodiacal sign,
> Dates of the Lunar Three,
> Dates and (usually) zodiacal signs of the planets' Greek-letter phenomena,
> Dates and timings of eclipses, or eclipse possibilities,
> Dates of solstices, equinoxes, and Sirius' Greek-letter phenomena.

As with the Normal Star Almanacs, a full edition of the Almanacs will be found in *ADART* Vol. VII; but as yet there has been no exhaustive collection and translation. Table 2.8 is a record of the Almanacs which were consulted during this research. As with Table 2.7, where the text was not simply translated from a copy in LBAT, the table shows whether the text had been previously translated, or whether I have translated it from somebody else's copy or from viewing the tablet itself.

Year (SE)	Museum number	LBAT number	Other notes
92	BM 40101+	*1118-9	text viewed in person
127	BM 32888	*1120	transliterated by John Steele
	Rm 786	1121	
128	BM 34232	1122	Copy also in SSB II
129	BM 33873	**1123	Copy in SSB I
147	MLC 2195	*1124	transliterated by John Steele
157	BM 35894	1125	
	BM 34470	1126	
158	BM 34121	1127	Copy also in SSB II
159	BM 41010	*1128	text viewed in person
160	BM 34345	1129	Copy also in SSB II
162	BM 35729	1130	
168	BM 35093+	1131	
175	BM 35366+	1132-3	

[102] The latest dated Diary is for year SE 251 (61-60 B.C.). Assuming Goal-Year methods, the earliest Diary that could have been used to create the Almanac for SE 385 would have been the Diary for 83 years previously, i.e. SE 302 (10-9 B.C.). See also Figure 2.1.

Year (SE)	Museum number	LBAT number	Other notes
178	BM 34051	1134	Copy also in SSB I & II
179	BM 33867	1135	
	BM 46106	1136	
183	BM 35551	1137	
185	BM 34949	1139	Copy also in SSB II
186	BM 46255	*1140	transliterated by Hermann Hunger
189	BM 45827+	1141-2	
190	BM 34298	1143	
	BM 45839	1144	
195	BM 35620	*1145	text viewed in person
	BM 45972	*1146	text viewed in person
197	BM 45716	*1147	transliterated by John Steele
198	BM 35187+	1148-9	
200	BM 38212	*1150	transliterated by John Steele
201	BM 35562	1151	
209	BM 33641	1152	
	BM 34042	1153	Copy also in SSB II
	BM 34991+	1154-5, *1156	Copies of 1154-5 also in SSB II
220	BM 35149	1157	Copy also in SSB II
	BM 35039	1158	Copy also in SSB II
226	BM 36016+	1159	
233	BM 35720	1160	
234	BM 33633	**1161	Copy in SSB II
	BM 35707+	1162-3	
	BM 34667+	1164-5, *1166	
	BM 45953+	**1167-8	Copy in SSB II
	BM 77257		text viewed in person
	BM 45929		
236	BM 43722	1169	Copy in SSB II
	BM 35098	1170	
	BM 35314+	1171, 1205, 1209, 1173	
	BM 33746+	**1172+1117	Copy of **1172 in SSB II

Year (SE)	Museum number	LBAT number	Other notes
	BM 45698	1174	Copy also in SSB II
237	BM 33736	1175	
241	BM 45919	1176	
242	BM 40496		text viewed in person
244	BM 41900+	1177	
	BM 46043	1178	
245	BM 31592+	*1179-80	transliterated by Hermann Hunger
246	BM 45729	*1181	transliterated by Hermann Hunger
247	BM 33798	1182	
248	BM 33485+	1183	
254	BM 46050	1184	
282	BM 34159	1185	
291?	BM 46105	1186	
297	BM 41468	1187	
300	BM 35570+	1188-9	
301	BM 33797	**1190	Copy in SSB I
303	BM 33784+	**1191-2	Copy in SSB II
305	BM 34614	1193	Translation in Sachs & Walker (1984)
	BM 34659	1194	Translation in Sachs & Walker (1984)
	BM 35429	1195	Translation in Sachs & Walker (1984)
	VAT 290+1836	**1196	Transliteration and (German) translation in Schnabel (1925)
342	MM 86.11.354		Transliteration and translation in Sachs (1976)
347	DT 143	*1197	Transliteration and translation in Sachs (1976)
355	BM 45982	*1198	Transliteration and translation in Sachs (1976)
372	BM 40083	*1199	Transliteration and translation in Sachs (1976)
	BM 40084	1200	Transliteration and translation in Sachs (1976)
385	Dropsie College	*1201	Transliteration and translation in Sachs (1976)

Table 2.8: Provenance of the extant Almanacs, showing whether they are copied in LBAT or elsewhere.

2.5 Other texts

This broad category covers various other non-mathematical texts which do not fall into the above classifications. Unlike the above categories, it is difficult to generalise on the contents of these diverse texts. In general the texts either record lunar events, i.e. Lunar Six or eclipses (or both); or planetary events, i.e. Normal Star passages or planetary phenomena (or both) relating to, typically, one or two planets for some years. The timespan of the records collected in a lunar or planetary text can vary from one year to 70 years or more.

In many cases, as with the Goal-Year Texts, the records seem to have been copied directly from Astronomical Diaries. However, several of the texts focus on events which are not generally recorded in the Diaries, such as Mercury's stationary points[103] or longitudes of planetary phenomena.[104] Additionally, it is clear that some of the texts contain predictions and computations rather than copies of Diary observations. Most interesting are those, such as the Cambyses text,[105] which appear to contain data predicted using Goal-Year methods. This text mainly covers the events of year 7 of Cambyses' reign (-522/-521), nearly 300 years before the earliest extant Goal-Year Text. The fact that Goal-Year methods seem to have been in use from such an early date is obviously very intriguing, and useful for tracing the development of Goal-Year methods throughout the period – this will be discussed further in Chapter 4.

2.6 Timeline

We can be practically certain that the Babylonian astronomers would have been expected to produce Diaries and predictive texts for each year that they were employed. Certainly, it appears that astronomers producing Goal-Year Texts had a practically complete archive of former Diaries to work from.[106] However, as established earlier, only a small percentage of these texts are still in existence.[107] A lot of the research presented here involves comparing records in the different text types, and so it is important to show how relatively little overlap there is between the texts. Figure 2.1 shows to which years during the Late Babylonian period a Diary, Goal-Year Text, Normal Star Almanac or Almanac has been dated, from -400 to 75 AD.[108]

The figure shows that, although the various non-mathematical texts span the entire period, very few of them are pre-Seleucid. All of the pre-Seleucid texts are Diaries, although the earliest dated Goal-Year Texts would have included some pre-Seleucid Mars and Jupiter records. Note that, even when the Diaries become relatively plentiful in the 4th century B.C., it is a full century before the earliest example of another text type is dated. Also, note that the Almanacs generally are dated to much later on in the period, with the latest Almanacs having a date of more than 100 years after the latest examples of any of the other text types. This has obvious implications for the amount of possible overlap between the text types.

Nevertheless, in the 2nd and 3rd centuries B.C. texts covering overlapping years are

[103] *ADART* Vol. V, No. 85.
[104] *ADART* Vol. V, No. 74. Analysed in Steele (2000c).
[105] *ADART* Vol. V, No. 55, see Britton (2007b) for a full analysis.
[106] The very few cases where a Diary was clearly *not* available, demonstrated with a remark such as "Year 2 […] the passings of Jupiter in Aquarius and Pisces are missing" (*ADART* Vol. VI No. 7, Obv. 3), only serve to highlight that the Babylonian astronomers almost always had all the past records that they needed.
[107] Hunger (1999) estimates around 5%.
[108] This figure follows Sachs (1974), Figure 2 of which is an equivalent timeline showing only the dates of Astronomical Diaries. Since the publication of that paper a few more Diaries have been identified and dated, and some have been redated; however the general trend of Sachs' figure is still applicable now.

common. Some years (SE 158 and 175) even have all four text types still in existence. Of course, it is also important to remember that many of the texts are damaged or partially broken away, and Diaries cover less than a full year in any case; so even when different types of text exist for the same year, there is no certainty that their remaining records will necessarily overlap.

Note: Diaries also exist for years: -651, -567, -463, -453 and -418

D=Diaries, G=GYT, N=NSA, A=Almanac

Year	D	G	N	A	SE
-400					
-399					
-398					
-397					
-396					
-395					
-394					
-393					
-392					
-391	■				
-390					
-389					
-388					
-387					
-386					
-385					
-384	■				
-383					
-382	■				
-381	■				
-380	■				
-379	■				
-378	■				
-377					
-376					
-375	■				
-374					
-373	■				
-372	■				
-371					
-370	■				
-369	■				
-368	■				
-367					
-366	■				
-365					
-364					
-363					
-362					

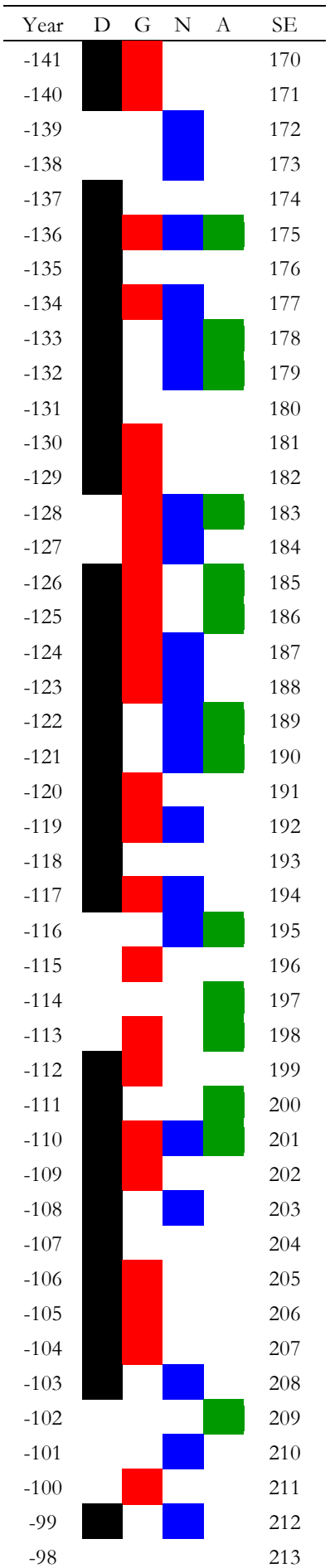
Year	D	G	N	A	SE
-361					
-360					
-359					
-358					
-357	■				
-356					
-355					
-354					
-353					
-352					
-351					
-350					
-349					
-348	■				
-347					
-346	■				
-345					
-344					
-343	■				
-342	■				
-341					
-340					
-339					
-338	■				
-337					
-336					
-335					
-334					
-333	■				
-332	■				
-331					
-330	■				
-329	■				
-328	■				
-327					
-326					
-325					
-324	■				
-323					
-322	■				
-321	■				
-320					
-319					
-318					

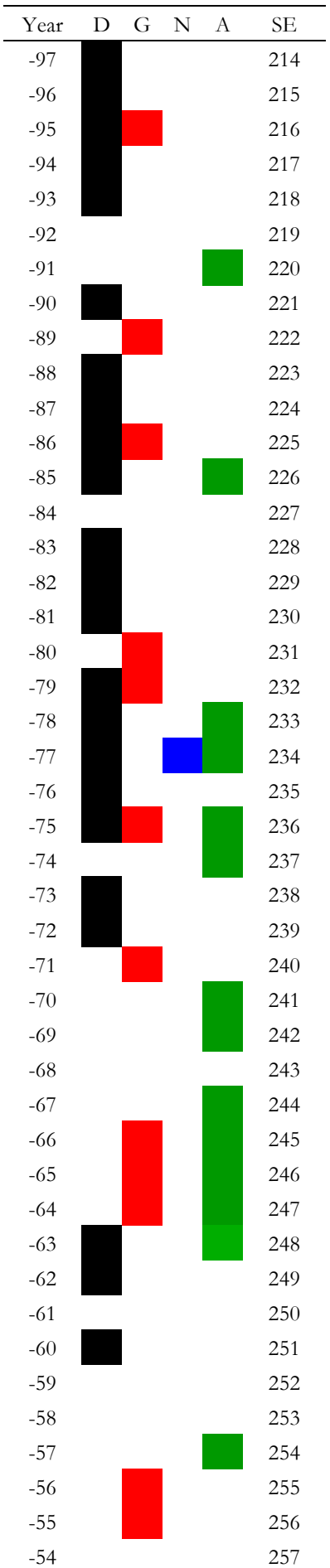
Year	D	G	N	A	SE
-317					
-316					
-315					
-314					
-313					
-312					
-311				Seleucid Era	
-310					1
-309	■				2
-308	■				3
-307					4
-306					5
-305					6
-304					7
-303					8
-302	■				9
-301	■				10
-300	■				11
-299	■				12
-298					13
-297					14
-296					15
-295					16
-294	■				17
-293	■				18
-292			■		19
-291	■				20
-290					21
-289	■				22
-288	■				23
-287	■				24
-286	■				25
-285					26
-284	■				27
-283	■				28
-282					29
-281	■				30
-280			■		31
-279					32
-278	■				33
-277	■				34
-276	■				35
-275					36
-274					37

Year	D	G	N	A	SE
-273	■				38
-272					39
-271			■		40
-270	■				41
-269					42
-268					43
-267					44
-266	■				45
-265					46
-264	■				47
-263	■				48
-262	■				49
-261	■			■	50
-260	■		■		51
-259	■				52
-258					53
-257	■				54
-256	■		■		55
-255	■				56
-254	■				57
-253	■		■		58
-252					59
-251	■		■		60
-250					61
-249	■				62
-248	■				63
-247	■				64
-246	■				65
-245	■				66
-244					67
-243			■		68
-242	■				69
-241	■		■		70
-240	■				71
-239	■				72
-238	■				73
-237	■				74
-236					75
-235		■			76
-234	■				77
-233					78
-232	■	■			79
-231			■		80
-230	■	■			81

Year	D	G	N	A	SE
-229					82
-228					83
-227					84
-226					85
-225					86
-224					87
-223					88
-222					89
-221					90
-220					91
-219					92
-218					93
-217					94
-216					95
-215					96
-214					97
-213					98
-212					99
-211					100
-210					101
-209					102
-208					103
-207					104
-206					105
-205					106
-204					107
-203					108
-202					109
-201					110
-200					111
-199					112
-198					113
-197					114
-196					115
-195					116
-194					117
-193					118
-192					119
-191					120
-190					121
-189					122
-188					123
-187					124
-186					125

Year	D	G	N	A	SE
-185					126
-184					127
-183					128
-182					129
-181					130
-180					131
-179					132
-178					133
-177					134
-176					135
-175					136
-174					137
-173					138
-172					139
-171					140
-170					141
-169					142
-168					143
-167					144
-166					145
-165					146
-164					147
-163					148
-162					149
-161					150
-160					151
-159					152
-158					153
-157					154
-156					155
-155					156
-154					157
-153					158
-152					159
-151					160
-150					161
-149					162
-148					163
-147					164
-146					165
-145					166
-144					167
-143					168
-142					169


Year D G N A SE
-141 170
-140 171
-139 172
-138 173
-137 174
-136 175
-135 176
-134 177
-133 178
-132 179
-131 180
-130 181
-129 182
-128 183
-127 184
-126 185
-125 186
-124 187
-123 188
-122 189
-121 190
-120 191
-119 192
-118 193
-117 194
-116 195
-115 196
-114 197
-113 198
-112 199
-111 200
-110 201
-109 202
-108 203
-107 204
-106 205
-105 206
-104 207
-103 208
-102 209
-101 210
-100 211
-99 212
-98 213


Year D G N A SE
-97 214
-96 215
-95 216
-94 217
-93 218
-92 219
-91 220
-90 221
-89 222
-88 223
-87 224
-86 225
-85 226
-84 227
-83 228
-82 229
-81 230
-80 231
-79 232
-78 233
-77 234
-76 235
-75 236
-74 237
-73 238
-72 239
-71 240
-70 241
-69 242
-68 243
-67 244
-66 245
-65 246
-64 247
-63 248
-62 249
-61 250
-60 251
-59 252
-58 253
-57 254
-56 255
-55 256
-54 257

Year	D	G	N	A	SE
-53					258
-52					259
-51					260
-50					261
-49					262
-48					263
-47					264
-46					265
-45					266
-44					267
-43					268
-42					269
-41					270
-40					271
-39					272
-38					273
-37					274
-36					275
-35					276
-34					277
-33					278
-32					279
-31					280
-30					281
-29					282
-28					283
-27					284
-26					285
-25					286
-24					287
-23					288
-22					289
-21					290
-20					291
-19					292
-18					293
-17					294
-16					295
-15					296
-14					297
-13					298
-12					299
-11					300
-10					301

Year	D	G	N	A	SE
-9					302
-8					303
-7					304
-6					305
-5					306
-4					307
-3					308
-2					309
-1					310
0					311
1					312
2					313
3					314
4					315
5					316
6					317
7					318
8					319
9					320
10					321
11					322
12					323
13					324
14					325
15					326
16					327
17					328
18					329
19					330
20					331
21					332
22					333
23					334
24					335
25					336
26					337
27					338
28					339
29					340
30					341
31					342
32					343
33					344
34					345

Year	D	G	N	A	SE
35					346
36					347
37					348
38					349
39					350
40					351
41					352
42					353
43					354
44					355
45					356
46					357
47					358
48					359
49					360
50					361
51					362
52					363
53					364
54					365
55					366
56					367
57					368
58					369
59					370
60					371
61					372
62					373
63					374
64					375
65					376
66					377
67					378
68					379
69					380
70					381
71					382
72					383
73					384
74					385
75					386

Figure 2.1: a timeline of Babylonian years from -400 to 75 AD, showing to which years an extant Astronomical Diary, Goal-Year Text, Normal Star Almanac or Almanac has been dated. Note that there is only a particularly significant overlap in the 3rd and 2nd centuries BC.

2.7 The source of the Goal-Year Texts' records

As stated above, it is normally assumed that the records in the Goal-Year Texts were copied from the Astronomical Diaries.[109] Table 2.9 shows the result of comparing 70 records of the same event, found in a Diary and a Goal-Year Text. Only records where a date and/or a distance measurement was preserved in each text were considered. The full details of the records can be found in Appendix B.

	Number of comparisons		
Planet	Total	Matching	Not matching
Jupiter	5	3	2
Venus	21	17	4
Mercury	28	21	7
Saturn	9	8	1
Mars	7	5	2
All	70	54	16

Table 2.9: a summary of comparisons of Diary and Goal Year Text records, to show whether the planetary record in the two texts matches or not.

Comparing the entries shows that often a Diary and a Goal-Year Text contain exactly the same record, word-for-word. In these cases the Goal-Year Text records must almost certainly have been copied from the Diary. However, in a lot of cases the recorded date or distance varies in the two texts; yet, this does not rule out the Diary being the source of these records too. As established in §2.1.3, when multiple observers were involved in carrying out observations they could often disagree regarding measured distances or times of events, and less often regarding dates of events (see Tables 2.3 - 2.5). It could be that the Goal-Year Text was copied from a near-duplicate Diary which no longer exists.

Equally, one text often gives a detailed, verbose account of an event while the other has an extremely short, terse entry for the same event. Again, this does not rule out a connection between the two texts. A few examples, taken from Appendix B, will illustrate this further:

> 14 GU_4-UD *ina* ŠÚ *ina* ABSIN 2 ½ KÙŠ *ár dele-bat ana* ŠÚ GUB IGI KUR NIM-*a* 16 *na-su in* 12 IGI
> "The 14th, Mercury's first appearance in the west in Virgo, it stood 2 ½ cubits behind Venus to the west[sic]; it was bright (and) high, sunset to setting of Mercury: 16°; (ideal) first appearance on the 12th."
> (*ADART* Vol. II No. -186C, Rev. 11-12)

> ZÍZ 14 GU_4-UD *ina* ŠÚ *ina zib*^{mes} 2 ½ KÙŠ *ár dele-bat ana* N[IM GUB IGI KU]R NIM-*a* 16 *na-su in* 12 IGI
> "Month XI, the 14th, Mercury's [first appearance] in the west in Pisces, [it stood] 2 ½ cubits behind Venus to the east; [it was bri]ght (and) high, sunset to setting of Mercury: 16°; (ideal) first appearance on the 12th."
> (*ADART* Vol. VI No. 53, Obv. 20'-21')

The Diary entry in this case comes from an end-of-month planetary summary. The two records are clearly extremely similar; the only difference is the relevant zodiacal sign, and

[109] For example Kugler (1924), Sachs (1948) onwards.

other nearby records show that "Virgo" is an error for "Pisces" here.

> *in* 14 GU_4-UD *ina* NIM *ina* TIL GU ŠÚ
> "Around the 14th, Mercury's last appearance in the east in the end of Aquarius."
> (*ADART* Vol. III No. -163C_1, Rev. 3')

> [Š]E 17 ŠÚ *šá* GU_4-]UD *ina* NI]M [*ina*] *ẓib*^{me} TA 14 *ina* TIL GU *ki* PAP NU IGI
> "[Month] XII, the 17th, Mercury's last appearance [in the ea]st [in] Pisces: from the 14th in the end of Aquarius, when I watched I did not see it."
> (*ADART* Vol. VI No. 69, Obv. 31-32)

The Diary entry again comes from an end-of-month planetary summary, and is notably briefer than the Goal-Year Text's entry.

§2.1.2, concerning planetary summaries, showed that the planetary summary at the end of a month could record a different dates for the same Greek-letter phenomenon than the observation during the month, particular when an "ideal" date was also recorded. The above examples, and the further examples in Appendix B, demonstrate that some Goal-Year Texts copied the observed date of a planetary event from a Diary, and some copied the ideal date.

These results match the findings of Hunger.[110] He compared 93 Diary and Goal-Year Text records of the same event and found differences in 20 cases. In the same paper he also warns that he previously "restored broken passages in the edition of the Diaries from a corresponding Goal year text" but that he is "not so sure about the certainty of restoring anymore"[111]! For the text comparisons outlined in this work, it is important to be aware of when modern scholars have restored broken passages. Evidently, if we wish to develop an understanding of Babylonian astronomical methods it is particularly crucial to know whether numbers and measurements to be analysed come from Babylonian writing or modern restorations.

2.8 The source of the Normal Star Almanacs' and Almanacs' records

There are no "instruction manuals" remaining to tell us how the Babylonian Astronomers produced the predictions in the Normal Star Almanacs and Almanacs. However, the events they predict are all of a periodic nature so we can be reasonably sure that any method employed to make the predictions would have made use of their periodicity. With this in mind, we can consider a few theories, outlined in Chapter 1, concerning the origins of the predictive texts.

One possibility is that the predictions were derived using the mathematical ephemerides found in *ACT*.[112] A few of the remaining extant Normal Star Almanacs or Almanacs cover years which overlap with ephemerides texts, and so the dates of Greek-letter phenomena predicted in the texts and in the *ACT* schemes can be compared. Table 2.10 summarises the results of these comparisons, and the full details of the records being compared can be found in Appendix C.

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[110] Hunger (1999).
[111] Hunger (1999), p. 83.
[112] Neugebauer (1955).

		Number of comparisons			
Planet	System	Total	Matching	Not Matching	Percentage matching
Mercury	A_2	0			
Mercury	A_1	58	10	48	17.24%
Venus	A_0	2	0	2	0.00%
Venus	A_1	3	1	2	33.33%
Venus	A_2	9	3	6	33.33%
Mars	A	4	0	4	0.00%
Jupiter	A	24	1	23	4.17%
Jupiter	A'	38	2	36	5.26%
Jupiter	B	16	0	16	0.00%
Jupiter	B'	1	0	1	0.00%
Saturn		3	0	3	0.00%

Table 2.10: comparisons of Greek-letter phenomena predictions from the Normal Star Almanacs or Almanacs with ACT ephemerides, showing whether the date of a planetary event predicted in these two types of text matches or not

It is immediately clear from Table 2.10 that the *ACT* ephemerides were *not* the source of the Normal Star Almanacs' or Almanacs' predictions of Greek-letter phenomena. The dates of events rarely agree, and are on occasion significantly different – 12 days or more. The only possible correlation is for Mars, System A where all of the phenomena dates are 6 days earlier in the predictive texts than in the *ACT* ephemerides. However, given that this result is derived from comparing the mere four available record pairs, it is certainly not a large enough amount of data to draw any further conclusions. In total around 10% of the comparisons agree on the date of an event, which is as much as we might expect the dates to overlap by coincidence.

An additional problem is that the *ACT* schemes do not directly predict passages of planets by Normal Stars, which would be necessary for the creation of Normal Star Almanacs. It seems that this would have been a more complicated process than calculating Greek-letter phenomena. Firstly, the daily longitude of the planet would have to be computed; these longitudes could then be compared with a star catalogue to determine the dates when the planet passed a Normal Star. An extremely small number of the ephemeris texts calculate the daily motion of Mercury or Jupiter,[113] and it is possible that texts existed to calculate the motions of the other planets too, but it seems that this process would have been somewhat laborious. According to Neugebauer the daily longitudes in these texts were calculated by interpolating between dates and longitudes of Greek-letter phenomena, in a scheme involving both the first and second derivatives of the daily longitude.[114]

Secondly, the daily latitude of the planet would have to be computed, so that the distance between the planet and Normal Star at the time of the passage could be calculated; there is no evidence that these steps were taken with the *ACT* ephemerides. Therefore, the *ACT* ephemerides need not be considered further as a source of the Normal Star Almanacs' and Almanacs' predictions.

Another suggestion is that the predictions were derived empirically, i.e. from the planetary periods and records found in the Goal-Year Texts. The primary argument in favour of this is that Goal-Year Texts are arranged in separate sections for each planet, which is not very convenient to refer to during the goal year itself. Normal Star Almanacs and Almanacs contain the same types of records but in chronological order for the prediction year, and so logically one might suggest that they consist of Goal-Year Text data rewritten

[113] Neugebauer (1955), texts 310 and 650-655.
[114] See the commentaries to texts 310 and 654, in Neugebauer (1955) pp 326-328 and 354-355 respectively.

chronologically for ease of use.

The merits of this theory will be discussed at length in Chapters 5 and 6. An argument against the theory is that the Goal-Year Texts rarely give the dates of planets reaching new zodiacal signs, and never explicitly contain the planetary position summaries at the beginning or end of a month which the Almanacs predict. As discussed in the previous chapter, it is not known exactly how the zodiacal sign boundaries were determined in Babylonian astronomy, and so the planetary positions in the Almanacs could simply have been deduced by reference to the Greek-letter phenomenon and Normal Star passage records in the Goal-Year Texts. The issues of the zodiacal signs' boundaries is examined further in the following chapter.

Chapter 3

Some outstanding issues relating to planetary records

This chapter combines studies of several issues relating to the non-mathematical texts, which have not been completely solved in the previous literature. In this chapter, unlike the following chapters, the focus is not on matters directly relating to Goal-Year predictions of events, but instead on understanding the terminology of the records. The chapter covers the usage of specific stars in planetary passages and other contexts, and the ways in which the zodiacal signs were used.

3.1 The Normal Stars used in the predictive texts

Alexander Jones has published an extensive study of the Normal Stars used in Babylonian planetary observations.[115] This section adds to Jones' investigation by comparing his findings with the Normal Stars used in Babylonian planetary *predictions*, i.e. predictions from the Normal Star Almanacs. (The Almanacs predict planetary positions using zodiacal signs only, so need not be considered here.)

It is not easy to define exactly how many Babylonian Normal Stars there are. As mentioned in Chapter 1, the introduction to *ADART* Vol. I details 32 Normal Stars, with the authors explaining that there are (unnamed and unnumbered) others used much less often. Star lists from the Late Babylonian Period may often include several stars not on Sachs & Hunger's list.[116] Roughton and Canzoneri discuss two groups of stars in Sagittarius, which seem to have been used almost exclusively for positions of stations and eclipses rather than planetary passages.[117] It appears that a group of four stars was treated as one "Normal Star" in this context.

To help resolve the potential confusion, Jones divides the Normal Stars into two categories: the 28 "core" stars, which are used regularly and referred to nearly every time a planet or the Moon moves past them; and the "additional" stars, those encountered significantly less frequently in the texts.[118] He further divides the additional stars into "alternates", stars which are located close to a core star and are occasionally used instead; star groups used for stations and eclipses rather than passages, as mentioned above; and stars or star groups which are simply referred to extremely infrequently.

The situation found in the Normal Star Almanacs is simpler than that of the observational texts. In total 31 stars are used for predicting planetary passages: all of the core 28 stars, and the additional stars η and γ Cancri (used as alternatives to the core star δ Cancri) and δ Scorpii (used as an alternative to the core star β Scorpii). The usage of these alternate stars is discussed in the following two subsections.

There are various reasons that none of the other additional stars were used for predictions. Firstly, the additional star π Scorpii could also be regarded as an alternate to β Scorpii, but only in relation to lunar passages: π Scorpii is at a very negative latitude, hence only the Moon comes close to it and none of the planets. Given that the Normal Star Almanacs do

[115] Jones (2004).
[116] See for example Roughton, Steele and Walker (2004).
[117] Roughton & Canzoneri (1992).
[118] Jones (2004), pp. 482-3.

not attempt to predict lunar passages,[119] it is not surprising that π Scorpii does not appear.

Secondly, unlike in the observational texts, positions are not always recorded for predictions of stations or eclipses, and when they are recorded it is in terms of the planets' zodiacal sign rather than relative to a Normal Star. (See the sections on zodiacal signs later in this chapter.) Therefore, the stars and star groups which are used solely for observations of these types of events would not be found in the predictive texts. As for the very rare stars which are only used once or twice for planetary positions in the Diaries, it is not surprising that they do not show up in the much smaller extant number of Normal Star Almanacs.

3.1.1 Alternate Normal Stars in Cancer

Table 3.1a shows the longitudes and latitudes of the four Normal Stars in Cancer, shown for years SE 11 and SE 311.[120] The stars fall naturally into two pairs – η and θ Cancri both have approximately the same longitude, as do γ and δ Cancri. This is reflected in the Babylonian names for these stars:
MÚL IGI *šá* ALLA *šá* SI/ULÙ = Front star of the Crab to the north/south, referring to η and θ Cancri respectively;
MÚL *ár šá* ALLA *šá* SI/ULÙ = Rear star of the Crab to the north/south, referring to γ and δ Cancri respectively.
Note that these star names differ from each other only in one or two key words. This would very likely have been a potential source of error and confusion for the Babylonian astronomers, as it can be for modern scholars: one broken or wrongly copied sign can make it impossible to distinguish η or δ Cancri from θ or γ Cancri.

	Longitude/Latitude at -300 (year SE 11)	Longitude/Latitude at 0 (year SE 311)
η Cancri	93.5/1.4	97.6/1.4
θ Cancri	93.8/-0.1	98.0/-0.1
γ Cancri	95.6/3.0	99.8/3.0
δ Cancri	96.7/-0.0	100.9/0.0

Table 3.1a: the longitude and latitude of η, θ, γ and δ Cancri in the years -300 and 0 (Sachs & Hunger, 1988)

Why was δ Cancri used as the core star, and the other three only as alternatives to it? Jones points out that some earlier observational texts refer just to "the rear stars of the crab",[121] and the convention of using δ Cancri may simply have developed from this – using the brightest star out of a group as a reference point rather than the group as a whole. From Table 3.1a one might also speculate that δ Cancri was used more because it has a latitude of zero, i.e. it is exactly on the ecliptic and all the planets would therefore pass it by fairly closely. However, this is not a wholly convincing explanation as all of the other stars also have latitudes reasonably close to the ecliptic.

[119] The Goal-Year methods used for predicting planetary passages would not be as effective for lunar passages. Goal-Year methods predict passages to the nearest day or so, but the Moon moves extremely fast – 12° of longitude or more a day – potentially passing by several Normal Stars in less than a day. Therefore it is much more difficult to predict empirically which Normal Star the Moon would be seen near on a given night.
[120] Longitude and latitude values taken from Sachs & Hunger (1988); all of the extant Normal Star Almanacs fall within these dates (see Table 2.6 in the previous chapter).
[121] Jones (2004), p. 485.

Whatever the reasons were, the use of δ Cancri as a core star is certainly borne out by the records in the predictive texts. Table 3.1b lists the predictions of planets passing Normal Stars in Cancer, taken from the Normal Star Almanacs. There are 9 references to δ Cancri, compared with only 2 for η Cancri, 1 for γ Cancri, and none at all for θ Cancri. The table does not include any passages where the name of the Normal Star was broken, as discussed above.

Date	Record	Planet's longitude	Planet's latitude
Passages by η Cancri			
188, I 30	Mars 4 fingers above	96.1	1.6
189, XII 18	Mars 2 fingers above	93.9	2.2
Passages by γ Cancri			
188, II 7	Mars 1/2 cubit below	100.2	1.5
Passage by δ Cancri			
96, V ~20	Venus 20 fingers above [sic]	96.6	-2.2
107, XII ~15	Saturn 2 fingers above	98.6	0.4
133, IV 30	Venus 1 cubit above	96.5	-0.4
146, V 6	Mars 10 fingers above	99.1	0.9
172, III 13	Mercury 2 fingers above	100.9	1.2
189, V 18	Venus 2 fingers above	99.5	-0.1
189, XII 28	Mars 20 fingers above	98.5	2.1
201, III 1	Venus 1 cubit above	101.5	1.7
201, III 2	Mars 1/2 cubit above	100.9	1.2

Table 3.1b: the longitude and latitude of planets on the dates of Normal Star Almanac predictions of passages by η, γ and δ Cancri

The longitudes and latitudes in this table were taken from JPL's Horizons system,[122] calculated for the planet's position at midnight on the predicted date (or the date of closest approach when the date was broken). As always, the lack of available data prevents many conclusions being drawn from the table, particularly when the texts seem to contain several errors. For example, the two predicted distances for Mars' passages by η Cancri are inconsistent. Also, every one of the predictions involving δ Cancri expects the planet to pass *above* the star, even though in a few of the cases the planets' latitude is significantly lower than the star's and it would surely be observed passing below the star instead.

Finally, it is interesting to compare Table 3.1b with Jones' statement that "There appear to be no instances in which even a slow planet is recorded as passing by a front star and a rear star in this quartet"[123] given that here there are two texts which exactly predict such an event. The Normal Star Almanacs for years SE 188 and 189 both predict Mars passing by a front star of the Crab, followed by a rear star a few days later.

3.1.2 Alternate Normal Stars in Scorpio

Table 3.2a shows the longitudes and latitudes of two of the Normal Stars in Scorpio, shown for years SE 11 and SE 311 as before. Note that, as with the stars in Cancer, β and δ Scorpii fall on approximately the same longitude. In this case β Scorpii has a latitude notably closer to the ecliptic than δ Scorpii, and so one would indeed expect that it was

[122] See §1.4.1 for discussion of this tool.
[123] Jones (2004), p. 485.

used more often.

	Longitude/Latitude at -300 (year SE 11)	Longitude/Latitude at 0 (year SE 311)
β Scorpii	211.2/1.3	215.4/1.3
δ Scorpii	210.6/-1.7	214.7/-1.7

Table 3.2a: the longitude and latitude of β and δ Scorpii in the years -300 and 0 (Sachs & Hunger, 1988)

As with Cancer, Jones refers to early texts showing that these two stars (and π Scorpii) functioned as a single Normal Star referred to as the "head of the scorpion".[124] Again, the Babylonian names of the stars reflect this:
MÚL MURUB$_4$ *šá* SAG GÍR-TAB = the middle star of the Scorpion's head (δ Scorpii);
MÚL *e šá* SAG GÍR-TAB = the upper star of the Scorpion's head (β Scorpii).

Table 3.2b lists the records from the Normal Star Almanacs which predict planets passing by β or δ Scorpii; there are 8 references to β Scorpii and 4 references to δ Scorpii. Again, this is consistent with β being the "core" star and δ being the "alternate".

Date	Record	Planet's longitude	Planet's latitude
Passages by β Scorpii			
96, IX 2	Venus 2 fingers above	212.1	1.6
104, VIII 29	Venus 2 fingers […]	211.5	1.6
116, IX 28	Saturn 8 fingers above	214.9	2.3
133, VIII 5	Mercury 10 fingers above	205.8	2.7
173 VIII […]	Mercury […] above	213.2	1.6
184, IX 2	Mars […] below	214.9	0.6
192, VIII 8	Venus […] above	212.3	1.4
201, VIII 29	Mars 8 fingers below	216.9	0.3
Passages by δ Scorpii			
156, VII 3	Venus 4 fingers above	212.3	-0.8
184, VIII 11?	[Venus …] above	214.0	1.3
192, VI 10	[Mars …] above	215.6	-0.6
201, VI 8	Venus 10 fingers below	213.9	-2.7

Table 3.2b: the longitude and latitude of planets on the dates of Normal Star Almanac predictions of passages by β and δ Scorpii

As with Table 3.1b, the longitudes and latitudes in this table were taken from JPL's Horizons system, calculated for the planet's position at midnight on the predicted date (or the date of closest approach when the date was broken). The column showing calculated planetary latitudes is particularly significant in this case: all the negative planetary latitudes are found for predictions involving δ rather than β Scorpii. This confirms our expectations (as firmly as one can conclude from so little data) that δ Scorpii was an alternate star to β Scorpii, used for the occasions when the planet had a particularly negative latitude as it moved through the constellation.

[124] Jones (2004), p. 485.

Star name	LBAT no. of text	Babylonian Date		Record	Julian date	Days (tithi) since vernal equinox	Days (tithi) since Sirius' rising
MÚL-MÚL	*1118-9, Obv. 2	Alm, SE 92	Month I, 16?	MÚL-MÚL x […]	-219, 5, 1	34	
	*1030a, Rev. 4	NSA, SE 150	Month VIII, 3	KI KUR ŠAMÁŠ MÚL-MÚL *ina* ŠÚ [*ina*] ŠÚ	-161, 10, 31	220	
	*1032, Rev. 1	NSA, SE 156	Month VIII, 10	KI KUR ŠAMÁŠ MÚL<-MÚL> *ina* ŠÚ ŠÚ	-155, 11, 1	221	
	1154, Obv. 3	Alm, SE 209	Month II, 1	MÚL-MÚL *ina* NIM IGI	-102, 5, 12	46	
	1065, Obv. 6'	NSA, SE 212	Month II, 4	MÚL-MÚL *ina* NIM IGI	-99, 5, 11	44	
	1174,Obv. 2	Alm, SE 236	Month I, 29	MÚL-MÚL *ina* NIM IGI	-75, 5, 12	46	
	1174, Rev. 1	Alm, SE 236	Month VIII, 4	MÚL-MÚL *ina* ZALÁG *ina* ŠÚ ŠÚ	-75, 11, 10	231	
	1177, Obv. 2	Alm, SE 244	Month I, 27	MÚL-MÚL *ina* NIM [IGI …]	-67, 5, 11	45	
(MÚL) BIR	*1030a, Obv. 16	NSA, SE 150	Month IV, 20?	*ina* ZALÁG BIR *ina* KUR IGI	-161, 7, 22	117	
	*1030a, Obv. 23	NSA, SE 150	Month VI, 1	*ina* ZALÁG MÚL BIR *ina* [KUR] IGI	-161, 8, 31	158	
	*1032, Obv. 3	NSA, SE 156	Month I, 26	*ina* EN BIR *ina* ŠÚ ŠÚ	-155, 4, 23	25	
ŠU-PA	*1032, Obv. 18	NSA, SE 156	Month VI, 24	*ina* ZALÁG ŠU-PA *ina* KUR IGI	-155, 9, 16	174	61
NUN.ki	1129, Obv. 5'	Alm, SE 160	Month VI, 2	NUN.KI *ina* NIM IGI	-151, 9, 10	168	56
	1130, Obv. 6'	Alm, SE 162	Month V, 24[+x]	MÚL NUN.KI *ina* NIM […]	-149, 9, 11	169	55
	*1190, Obv. 8	Alm, SE 301	Month IV, 1	MÚL NUN.⌜KI⌝ ŠÚ	-10, 7, 13	109	
	*1190, Obv. 11	Alm, SE 301	Month V, 20	MÚL NUN.⌜KI x⌝	-10, 8, 30	158	45

Table 3.3: predictions of stars' rising and setting dates in the Normal Star Almanacs and the Almanacs.

3.2 Unusual mentions of star visibilities in the predictive texts

In addition to the Normal Stars, a very small number of the predictive texts contain references to certain stars' heliacal rising and setting dates. Four different stars (other than Sirius[125]) are found in this context, in a total of ten different Normal Star Almanacs or Almanacs. Surprisingly, there is no evidence of the Babylonian astronomers observing these stars' risings and settings in the Diary records.

Table 3.3 summarises these records and converts the date of the prediction into the Julian calendar.[126] Also shown are the number of tithi between the vernal equinox and the prediction date for each record, and the number of tithi between Sirius' rising and the prediction date for certain records. The reasons behind this are explained below.

The Babylonian names for these stars/constellations have been identified with the following:

- MÚL-MÚL, "the stars" = the Pleiades. This is certain, because MÚL-MÚL as a name for the Pleiades (or at least for their brightest star, η Tauri) also occurs in the texts as a Normal Star. It is also in agreement with the scheme for the heliacal rising of the Pleiades found in Atypical Text B[127] - that the Pleiades should rise 1 month 15 tithi after the vernal equinox. This makes it immediately clear from the table that the rising date predicted for SE 92 is ~11 days too early, and that the setting date predicted for SE 236 is ~10 days too late. As Neugebauer & Sachs point out this is easy to do, given the 11-day difference between the lunar and solar year, by choosing one row too high or low in a column of calculated dates.

Unfortunately, none of the other stars in Table 3.3 agree with the dates in the second, unknown column of Atypical Text B. This column requires an event 16 days after the vernal equinox.

- (MÚL) BIR, "the kidney star". The identity of this star has not been confirmed, although Reiner & Pingree state that *Kalūtum* = BIR "The Kidney" is a star in the constellation of NUN.KI "Eridu" (q.v.), possibly to be identified with ζ Puppis.[128] Hunger & Pingree's list of stars mentions the Kidney, but unusually they do not speculate on its identity.[129] MÚL.APIN does not mention a Kidney Star; there is one reference to "the bright red star which stands in the kidney of the Stag: the Deleter",[130] but it is clear that this is a different star.

The predicted dates from the Normal Star Almanacs do not allow any of this speculation to be confirmed or disproved. In total they predict only three dates for MÚL BIR, and it is obvious that at least one of these dates is totally wrong. No star could have two different heliacal risings separated by less than two months, as the predictions for SE 150 suggest. Hunger believes that the earlier of the two dates should be disbelieved, as the tablet is rather damaged at this point.[131] It is quite possible that the earlier of the two rising dates could in fact be a broken prediction of *Sirius'* heliacal rising, which according to the Uruk

[125] Sirius' rising and setting, as established in Chapter 2, were predicted as a matter of course in both the predictive texts and the Diaries.
[126] Using Parker & Dubberstein (1956) as usual.
[127] Neugebauer & Sachs (1967).
[128] Reiner & Pingree (1981), p. 4.
[129] Hunger & Pingree (1999), pp 271-277.
[130] Hunger & Pingree (1989), p. 28.
[131] H. Hunger, personal communication.

scheme should have taken place on day 16 of Month IV that year – very close to the date on the tablet.

- ŠU-PA = Boötes or principally Arcturus (α Boötis), the third brightest star in the sky.[132] This is mentioned in MÚL.APIN as rising 60 days after Sirius, a number in agreement with the one preserved rising date from a Normal Star Almanac.[133]

- (MÚL) NUN.KI, "the star of Eridu". The exact star is unknown, although the *constellation* of Eridu could be α+ Puppis[134] or "parts of Puppis and Vela"[135] according to Hunger & Pingree. Reiner & Pingree link NUN.KI to the constellation BIR (q.v.) and suggest ζ Puppis (again) or the nearby Canopus (α Carinae) for the principal star.[136] Canopus is surely a very plausible candidate for the star of Eridu; it is the second brightest star in the sky and yet does not seem to have any other Babylonian star designations linked to it. According to the Alcyone computer program,[137] Canopus would have been visible from Babylon and Uruk for the period between early September and early April.

In MÚL.APIN, the star of Eridu is said to rise 55 days after Sirius.[138] This is consistent with the dates in Table 3.3, and suggests that the rising date predicted for SE 301 is approximately 10 days too early. This could be another example of choosing the date in the wrong row of a table, or it could be that the recorded date should have been the 30th rather than the 20th. The date prediction is written at the end of a month, after predictions for the 27th and 28th, so a scribal error of 20 for 30 is a possibility.

Why do so few of the Almanacs and Normal Star Almanacs predict the dates of these stars? This is not just an example of a change of convention over the period, because the texts that record these predictions are dated to isolated years across a period of more than 200 years. A plausible explanation might lie in the fact that two of the texts – the Normal Star Almanacs for years SE 150 and SE 156 – definitely originate from the city of Uruk rather than Babylon. However, as previously established, many of the texts do not have good archaeological provenance, so we cannot be certain for each of the texts in Table 3.3 whether it is from Babylon or Uruk.

3.3 Boundaries of the Zodiacal Signs

The development of the zodiac in the fifth century B.C. provided Babylonian astronomers with a new means of specifying the position of the Moon or a planet. In analogy with the 'ideal year' of twelve 30-day months that appears in several earlier astronomical and astrological texts, the Babylonians divided the bands of the sky in which the sun, Moon and planets move into twelve segments, each one of which was subdivided into 30 parts.[139] Distances along these bands were measured by zodiacal signs and degrees within those signs.

As cited in the previous chapters, Huber showed that, for some of the zodiacal signs, the observed or predicted dates for when a planet will cross from one sign to another coincide

[132] Reiner & Pingree (1981), p. 4.
[133] Hunger & Pingree (1989), p. 53.
[134] Hunger & Pingree (1989), p. 138.
[135] Hunger & Pingree (1999), p. 272.
[136] Reiner & Pingree (1981), p.8.
[137] Again, see §1.4.4 for a discussion of this tool.
[138] Hunger & Pingree (1989), p. 53.
[139] Steele (2007a).

with the date of the planet passing by a particular Normal Star.[140] These studies imply that the Babylonian zodiac was fixed sidereally (i.e., with respect to the stars), rather than tropically (i.e., with respect to the equinoxes) as in Greek astronomy. The discovery of two Babylonian catalogues of Normal Stars listing the positions of the stars in degrees within zodiacal signs supports this conclusion.[141]

The zodiac (as described in Chapter 1) appears in five principal contexts within Babylonian astronomy:

> 1. The zodiacal sign in which a visible planet is located during a month is reported in the summary at the end of an Astronomical Diary. In later Diaries, beginning in the last quarter of the third century B.C., this information is supplemented with the date on which the planet crossed from one zodiacal sign to the next.
>
> 2. The zodiacal sign in which a visible planet is predicted to be located at the beginning of a month and the date on which the planet is expected to cross from one zodiacal sign to the next is recorded in the Almanacs.
>
> 3. The zodiacal sign in which a planet is located on the day of its first and last visibilities and (usually) at its stations is recorded in the Astronomical Diaries, the Normal Star Almanacs, the Almanacs, the Goal-Year Texts and in several planetary compilations. In some cases the zodiacal sign is qualified with the adjective "beginning" or "end".
>
> 4. The zodiacal sign in which the Moon is located during a lunar eclipse is occasionally recorded in the Astronomical Diaries, the Normal Star Almanacs, the Almanacs, the Goal-Year Texts and in some eclipse texts. In some cases the zodiacal sign is qualified with the adjective "beginning" or "end".
>
> 5. In the texts of mathematical astronomy the positions of the sun, Moon and planets are given in degrees and fractions within zodiacal signs.

The following sections focus on analysing the preserved records in categories 1 to 4 of the list, with the aim of improving our understanding of how the Babylonian astronomers used the zodiac in practice. In particular, they investigate these questions: Were the zodiacal signs of equal length? What was meant by "beginning" or "end" of a zodiacal sign?

Records of the dates of a planet's entry into a zodiacal sign appear in the summaries at the end of each monthly section of the Astronomical Diaries, beginning around the end of the third century BC. The records have a standard format: following the date is recorded the name of the planet, then the name of the zodiacal sign, and finally the technical term KUR. Sometimes this term is written with the addition of a phonetic complement KUR-*ád* and is to be read as a form of the Akkadian verb *kašadu* and literally means 'to reach' or 'to arrive'. For example:

> 17 *dele-bat* PA KUR-*ád*
> "The 17th, Venus reached Sagittarius"
> (*ADART* Vol. III No. –124B, Obv. 18′)

The dates of sign entries given in the Diaries were determined by the Babylonian

[140] Huber (1958).
[141] Roughton, Steele & Walker (2004), Sachs (1952a).

astronomers from observed passages of the planets by Normal Stars, either directly in the case of Gemini, Cancer and Aquarius whose beginnings coincide with ζ Tauri, β Geminorum and δ Capricorni respectively, or indirectly for the other signs.

The Almanacs also predict dates of planets' zodiacal sign entries, with terminology identical to that found in the Astronomical Diaries. These dates were presumably determined in a similar fashion to those in the Astronomical Diaries, except that predicted passages of the planets by Normal Stars (which are recorded in the Normal Star Almanacs), rather than observed passages, would have been used.

For this investigation, a thorough search of all dated Astronomical Diaries and Almanacs was undertaken to compile exhaustive lists of dated records of planetary sign entries. In total 103 records from Astronomical Diaries and 235 records from Almanacs were found, dating between –212 and –72, and –183 and +74 respectively. Appendix D provides details of these records.

The Julian date of each record was determined using the tables of Parker and Dubberstein,[142] supplemented by the calendrical data provided in *ADART* I-III. The tropical longitude of the planet on the date of the records was then determined using F. R. Stephenson and K. K. C. Yau's computer program based on the Bretagnon ephemeris.[143] The superior planets' longitudes were uniformly calculated for a Terrestrial Time (TT) of 20.00 hrs (corresponding to a local time of about 8pm at Babylon during the first few centuries B.C.); for the inferior planets the longitude were calculated for TTs of either 20.00 hrs or 4.00 hrs, depending upon whether the planet was seen as an evening or a morning star.

Before commencing a detailed analysis of this material, it is worth noting that there can be a considerable variation in the longitudes of the planets on the dates when they are said to enter a particular zodiacal sign. For example, in the Diary *ADART* Vol. III No. –140A (which covers the first half of year SE 171) Mars reaches Cancer on the 19th of Month I, two days before Venus reaches the same sign on the 21st. However, Mars's tropical longitude on that date is 86.04° whereas Venus's longitude is only 83.42° at the time when it enters Cancer. Similarly, the Almanac for SE 355 predicts that both Mercury and Venus will enter Capricorn on the 29th of month IX, but the longitudes of the two planets on that day are 269.06° and 267.86° respectively. Evidently, it was not always easy for the Babylonian astronomers to determine the positions of the boundaries of the zodiacal signs.

A possible contribution to the uncertainty in variation of the longitude of a sign boundary may come from the latitude of the planet. As described in §1.3.5.2, Jones showed that the date on which a planet passed directly above or below a star was in some cases defined by the passage of the planet across an imaginary line between two nearby stars at approximately the same longitude. The latitude of the planet will therefore affect the longitude of its passage point. However, this effect is insufficient to account for many of the discrepancies in the position of the sign boundary.

3.4 The Length of the Zodiacal Signs

If the boundaries of the zodiacal signs used by the Babylonian astronomers during their observations were defined by passages of a planet by a star (either directly or by a certain distance in front of or behind that star), it is legitimate to ask whether the signs were all of

[142] Parker & Dubberstein (1956).
[143] Bretagnon, Simon & Laskar (1985), as discussed in §1.4.3.

equal length. Textual evidence from the star catalogues and other sources indicates that the Babylonian astronomers interpreted the signs as being of equal length,[144] but how did this translate into observational practice? The dates when a planet enters a zodiacal sign recorded in the Astronomical Diaries and the Almanacs may be used to investigate this question: if the dates of the entry of a planet into two consecutive signs (in other words, the dates when it enters and leaves a particular sign) are preserved, we can use modern ephemerides to calculate the celestial longitude of the planet on the two dates and therefore the length of that sign.

Unfortunately, although there are many preserved records of the dates of sign entries, only 9 times in the Astronomical Diaries and 51 times in the Almanacs is the following sign entry also preserved, providing dates when the planet both entered and left the sign. The data gathered from the two sources have been kept separate to ensure that if there is any early or late bias in the predicted dates of sign entries in the Almanacs, this will not affect the determination of the lengths of individual zodiacal signs. By only using pairs of data from the same tablet, any systematic error in the dates of predicted sign entries caused, for example, by making insufficient corrections to the whole-year Goal-Year periods that were used to determine planetary passages by Normal Stars,[145] will be eliminated by taking the difference between the positions of beginning and end of a sign.

Since there are many more data for the Almanacs than for the Astronomical Diaries let us first analyse the Almanacs. Table 3.4 lists details for the 51 cases where the dates of a planet entering and leaving a zodiacal are preserved. The overall mean sign length is 30.31° with a standard deviation of 1.32° in the data. Of course, whatever the length of the individual signs, the mean sign-length will always be close to 30°, but the small standard deviation implies that *all* the signs were close to 30° in length. It is worth noting that an error of up to a degree could be caused by the potential uncertainty of ±1 day in our knowledge of the beginning of the Babylonian months.

It is possible that there is some small variation the mean lengths of the individual signs. For example, Aries and Cancer seem to be slightly over 30° in length, whereas Scorpio, Sagittarius and Capricorn all seem slightly under 30°. However, with such a small data sample we should be wary of drawing any conclusion from these discrepancies. Instead it seems most likely that all the zodiacal signs were in practice close to the ideal of 30° in length, but that any individual determination of the beginning or end of a sign could be off by up to a couple of degrees.

Table 3.5 shows the same analysis of the lengths of the zodiacal signs extracted from the Astronomical Diaries. The overall mean length of the zodiacal signs is 29.85° with a standard deviation of 0.94°. As with the Almanacs, the small standard deviation implies that the signs were all close to 30° in length. Unfortunately there are too few data to examine the zodiacal signs individually.

From this analysis of the dates when a planet enters and exits a zodiacal sign we can conclude that the zodiacal signs used in observational practice were intended to be, and closely were, of equal length. In any individual determination of when a planet entered a zodiacal sign, however, there could be a spread of up to a couple of degrees in where it was thought the sign began.

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[144] Steele (2007a).

[145] For details of these corrections, see Chapters 4 and 5; also Gray & Steele (2008).

Zodiacal Sign	Planet	Beginning of Sign		End of Sign		Sign Length	Mean
		Date	Trop. Long.	Date	Trop. Long.		
Aries	Mars	183 X 15	353.32	183 XII 8	26.45	33.13	
	Venus	183 XI 13	353.81	183 XII 16	26.85	33.04	
	Mars	234 II 28	355.17	234 IV 17	26.27	31.10	
	Venus	234 I 20	356.47	234 II 16	26.15	29.68	
	Mars	236 I 26	356.38	236 III 9	26.34	29.96	31.38
Taurus	Mars	157 III 10	27.34	157 IV 23	54.78	27.44	
	Venus	189 III 11	25.60	189 IV 10	55.97	30.37	
	Mars	189 III 24	26.47	189 V 11	55.26	28.79	
	Venus	234 II 16	26.15	234 III 12	57.41	31.26	
	Mars	236 III 9	26.34	236 IV 25	56.60	30.26	29.62
Gemini	Mars	129 IV 7	58.36	129 V 28	90.84	32.48	
	Venus	209 I 19	54.54	209 II 15	84.95	30.41	
	Mars	236 IV 25	56.60	236 VI 29	86.37	29.77	
	Venus	301 III 14	57.89	301 IV 8	86.62	28.73	
	Venus	385 I 6	57.75	385 II 2	88.75	31.00	30.48
Cancer	Mercury	178 III 13	82.97	178 IV 4	115.25	32.28	
	Mars	178 V 3	83.26	178 VI 24	116.24	32.98	
	Venus	190 II 2	85.29	190 II 28	115.08	29.79	
	Venus	209 II 15	84.95	209 III 10	115.10	30.15	
	Venus	236 II 26	83.93	236 III 21	114.60	30.67	
	Venus	301 IV 8	86.62	301 V 4	117.12	30.50	
	Venus	372 II 22	86.67	372 III 18	119.48	32.81	
	Venus	385 II 2	88.75	385 II 28	119.01	30.26	31.18
Leo	Venus	178 V 15	111.46	178 VI 9	143.75	32.29	
	Venus	236 III 21	114.60	236 IV 15	144.00	29.4	
	Venus	301 V 4	117.12	301 V 28	146.87	29.75	30.48
Virgo	Mars	301 III 16	146.77	301 V 5	177.20	30.43	
	Venus	355 VI 21	147.97	355 VII 16	178.24	30.27	30.35
Libra	Venus	201 V 4	175.91	201 VI 1	206.30	30.39	
	Venus	355 VII 16	178.24	355 VIII 11	207.93	29.69	
	Venus	372 V 9	177.01	372 VI 5	207.34	30.33	30.14
Scorpio	Venus	201 VI 1	206.30	201 VII 1	236.12	29.82	
	Venus	236 VI 8	207.13	236 VII 2	235.73	28.60	
	Venus	355 VIII 11	207.93	355 IX 5	237.87	29.94	29.45
Sagittarius	Venus	236 VII 2	235.73	236 VII 28	265.86	30.13	
	Venus	355 IX 5	237.87	355 IX 29	267.86	29.99	
	Mercury	355 IX 8	240.88	355 IX 29	269.06	28.18	
	Venus	372 VII 3	237.54	372 VIII 3	267.35	29.81	29.53
Capricorn	Venus	183 VIII 25	264.31	183 IX 21	293.76	29.45	
	Mercury	209 X 9	263.96	209 XI 1	293.26	29.30	
	Venus	236 VII 28	265.86	236 VIII 26	294.98	29.12	
	Mars	305 VIII 8	266.20	305 IX 16	295.74	29.54	29.35
Aquarius	Venus	183 IX 21	293.76	183 X 15	322.65	28.89	
	Mars	209 IX 18	294.05	209 X 28	325.27	31.22	
	Venus	209 XI 28	291.45	209 XII 29	324.72	33.27	
	Venus	236 VIII 26	294.98	236 X 5	324.30	29.32	
	Mars	305 IX 16	295.74	305 X 26	325.90	30.16	30.57

Zodiacal Sign	Planet	Beginning of Sign		End of Sign		Sign Length	Mean
		Date	Trop. Long.	Date	Trop. Long.		
Pisces	Mars	183 VIII 27	323.91	183 X 15	353.32	29.41	
	Venus	183 X 15	322.65	183 XI 13	353.81	31.16	
	Mars	234 I 17	326.17	234 II 28	355.17	29.00	
	Mars	305 X 26	325.9	305 XII 7	355.94	30.04	29.90

Table 3.4: The length of zodiacal signs taken from the Almanacs.

Zodiacal Sign	Planet	Beginning of Sign		End of Sign		Sign Length
		Date	Trop. Long.	Date	Trop. Long.	
Taurus	Mars	174 II 30	25.37	174 IV 16	56.19	30.82
	Venus	234 II 16	26.15	234 III 12	57.41	31.26
Gemini	Venus	206 I 2	55.70	206 I 27	85.17	29.47
	Venus	234 III 12	57.41	234 IV 7	86.63	29.23
Cancer	Venus	206 I 27	85.17	206 II 24	114.81	29.64
	Venus	234 IV 7	86.63	234 V 2	117.42	30.79
Virgo	Venus	179 VII 1	145.83	179 VII 28	175.02	29.19
Sagittarius	Venus	187 IX 17	237.14	187 X 10	265.51	28.36
Pisces	Venus	186 I 2	322.30	186 I 29	352.21	29.91

Table 3.5: The length of zodiacal signs taken from the Diaries.

3.5 The "Beginning" and "End" of a Zodiacal Sign

The earliest Astronomical Diaries of the sixth and seventh centuries B.C. include observations of the planets' Greek letter phenomena recorded relative to zodiacal constellations. In these early texts the planet may be said to be, for example, "behind" (*ár*) or "in front of" (*ina* IGI) a constellation. After the development of the zodiac in the fifth century B.C., observations and predictions of planetary phenomena in all of the main non-mathematical text types are said to occur "in" (*ina*) a zodiacal sign.[146] Most of these records simply state that the event happened, for example, "in Libra", but a subset of the records — up to a third — are more specific with the position given in the form of "in the beginning (SAG) / end (TIL) of Libra".

The same terminology is used in all of the observational or predictive texts for reporting positions in the beginning or end of a zodiacal sign. The following examples demonstrate the standard terminology:

> ⌜GAN⌝ 21 ⌜GENNA *ina* MÁŠ ŠÚ⌝ ZÍZ 2 ⌜GENNA⌝ *ina* TIL ⌜MÁŠ IGI⌝
> "Month IX, the 21st, Saturn's last appearance in Capricorn. Month XI, the 2nd, Saturn's first appearance in the end of Capricorn."
> (*ADART* Vol. VI, No. 8, Obv. 10′ (Goal-Year Text for S.E. 94))

[146] Rochberg-Halton (1991), pp. 109-111.

22 MÚL-BABBAR *ina* TIL *zib*^{ME} UŠ
"The 22nd, Jupiter stationary in the end of Pisces."
(LBAT 1195, Obv. 8 (Almanac for S.E. 305))

Almost all of the records containing zodiacal signs are observations or predictions of the planets' Greek letter phenomena. In practice this means that most of the data relate to the first and last visibilities of the planets, particularly those of Mercury. In part this is because Mercury's appearances and disappearances occur significantly more frequently than any other planetary phenomenon, and in part because records of stationary points and acronychal risings do not always indicate the planet's location. As mentioned in the previous sections, observational records of stationary points quite often give the planet's position relative to a Normal Star instead of a zodiacal sign, and only one example was found where the zodiacal sign of a planet's acronychal rising was observed or predicted:

10 AN *ina* TIL MÚL.A *ana* ME-A
"The 10th, Mars's acronychal rising in the end of Leo."
(MLC 1860, rev. 15 (Normal Star Almanac for S.E. 82))

It is also necessary to take into account the fact, as discussed in Chapter 2, that the Diaries record these observations in both the main body of the monthly section and in the end of month summaries. For example, in Diary No. –168A we read in the main part of the entry for Month V:

24 *dele-bat ina* ŠÚ *ina* TIL ABSIN IGI 8,30 *na-su in* 22 IGI
"The 24th, Venus's first appearance in the west in the end of Virgo; sunset to setting of Venus: 8°30′; (ideal) first appearance on the 22nd."
(*ADART* Vol. II No. –168A, Obv. 10)

However, at the end of the month we find:

in 22 *dele-bat ina* ŠÚ *ina* ABSIN IGI
"Around the 22nd, Venus's first appearance in the west in Virgo"
(*ADART* Vol. II No. –168A, Obv. 13)

This common practice of "ideal" dates in the later Diaries was discussed in detail in the previous chapter; here the important point to remember is that the observations recorded in the main text for the month and those in the summaries do not always match. Occasionally, the Babylonian astronomers reported that the planet was located in a different sign of the zodiac on the ideal and observed dates. For example, a first appearance of Mercury was observed in the beginning of Gemini on the 30th of Month I in S.E. 193 but should apparently have been seen three days earlier:

30 GU4-UD *ina* ŠÚ [*ina* SA]G MAŠ-MAŠ 2/3 KÙŠ *ina* IGI GENNA ⌜1⌝ ½ KÙŠ *ana* SI NIM IGI K[UR? NIM-*a*? nn *na-su in*? 27 *ina* TIL MÚL-MÚ]L IGI
"The 30th, Mercury's first appearance in the west [in the beginn]ing of Gemini, 2/3 cubit in front of Saturn, 1½ cubits high to the north; it was br[ight? and high?, sunset to setting of Mercury: nn°;] (ideal) first appearance [on the 27th in the end of Taur]us."
(*ADART* Vol. III No. –118A, Obv. 15)

The ideal date in the above record has presumably been restored from the end of month

summary, in which the ideal date of the first visibility is recorded and Mercury's position on this ideal date is recorded as the *end* of Taurus:

> *in* 27 GU4-UD *ina* ŠÚ *ina* TIL MÚL-MÚL IGI
> "Around the 27th, Mercury's first appearance in the west in the end of Taurus."
> (*ADART* Vol. III No. –118A, Obv. 18)

We can conclude from examples such as this that even if we cannot be sure whether the date given for a record was observed or ideal, we can expect that the planets' beginning / end / otherwise status is correct for that date.

To understand when the terms "beginning" or "end" were applied to the non-mathematical observations and predictions, an exhaustive database was compiled of records of this type which refer to a planet's location in zodiacal sign at the time of a Greek-letter phenomenon. The full details of the records in the database can be found in Appendix E. The database contains all such entries for which the Babylonian year, month and day are known; this included ones where the date is specified as "around the (day number)", but not those for which the day number is missing or partially broken.

For each record the Babylonian date has been converted into a Julian date using Parker and Dubberstein's tables and the longitude of the planet in question on each date was then determined using the Bretagnon ephemeris. A TT of 20.00 for evening observations and 04.00 for morning observations of inferior planets was assumed, and a local time of 00.00 for all observations of superior planets.

Finally, the tropical longitudes needed to be corrected to account for precession. Huber discovered that the Babylonian zodiac was aligned with certain stars, implying that the zodiac will gradually shift relative to a tropical frame of reference as a result of precession.[147] Huber estimated that the zero-point of the Babylonian zodiac in –100 was at a tropical longitude of 4°22′. The rate of precession is about 0.013825° per year and, by adjusting for precession, we therefore find that Huber's result corresponds to a zero-point at about 3.08° in year 0. Therefore, the tropical longitudes were converted to Babylonian sidereal longitudes using the following equation:

$$\lambda_B = \lambda_T + 3.08 + 0.013825y$$

where λ_B is the Babylonian longitude, λ_T is the tropical longitude and y is the astronomical year number. This equation was most recently analysed by Gray & Steele, who recommend continued use of Huber's equation.[148]

In 16 of the database's records, the calculated longitude of the planet on the date given in the text indicated that it was a considerable distance away from the zodiacal sign recorded in the text – usually more than 30°, i.e. the planet was not even in the neighbouring zodiacal sign – which are clearly errors. The discrepancies could be due to a scribal error of writing down the wrong sign; occasional copying errors are inevitable when considering a large data set such as this, where records have been copied and recopied from other texts (such as data in Goal-Year Texts having been copied from Astronomical Diaries). These 16 records have been omitted in the subsequent investigations.

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147 Huber (1958).
148 Steele & Gray (2007), pp. 448-449.

However, there is a clear difference between these omitted cases and the few records where a planet's longitude was only a small number of degrees into the adjacent zodiacal sign. The latter records have been included unless there is further evidence to treat them as an error such as the case of Mars's first appearance recorded in the Astronomical Diary No. –144 for Month VI:

> *in* 13 AN *ina* ABSIN IGI *in* 10+x [...] AN ABSIN KUR
> "Around the 13th, Mars's first appearance in Virgo; around the 10[+xth, ...] Mars reached Virgo"
> (*ADART* Vol. III No. –144, Obv. 13′)

On this date Mars's longitude was in fact about 146°, i.e. 4° before the end of Leo, at the time of its first appearance. This record has therefore not been included in the analysis, as it seems more likely that this is a copying error rather than the Babylonian astronomers intending Mars's first appearance to be in a zodiacal sign it only reaches several days later. Records in the Diaries are virtually always listed chronologically, and so Mars's entry into Virgo must have occurred after the 13th.

Note that texts which contain observations of planets in zodiacal signs but which do *not* include at least one taking place in the "beginning" or "end" of a sign have not been included in the database. This is because it is evident from the records that the practice of mentioning the beginning/end of a sign was not always followed. It is impossible to distinguish between a text that does not mention beginning/end by choice (which it would not be useful to include) and one that does not mention beginning/end because nothing happened in the beginning/end of a sign at that time, or because a relevant portion of the text has broken away.

The breakdown of remaining records used for the analysis is:

Text Type	Total Records	"Beginning"	"End"
Diaries	247	39	42
Goal-Year Texts	214	24	27
Normal Star Almanacs	135	17	17
Almanacs	129	11	15

For each corrected planetary longitude, the longitude of the beginning of its zodiacal sign was subtracted (0° for Aries, 30° for Taurus and so on) to give a measure of how far into the zodiacal sign the planet was at that time. In other words, any points for which this value was above 30° or below 0° were in fact in the neighbouring zodiacal sign at the time of observation. This data is summarized in Figures 3.1a (Astronomical Diaries), 3.1b (Goal-Year Texts), 3.1c (Normal Star Almanacs), and 3.1d (Almanacs). The x-axis shows the points in chronological order according to the date of the observation or prediction, spreading the data equidistantly along the axis rather than representing any particular time scale. This is for ease of reading, as a linear timescale would result in a more confusing figure, with the data points for any particular year being shown too close together for clarity and long empty gaps along the time axis.

The figures show that, in general, "beginning" observations fall mostly between 0° and 5° of a zodiacal sign, and "end" observations fall mostly between 25° and 30°. This result is consistent across each type of text, allowing us to suggest the conclusion that the Babylonian astronomers considered the "beginning" and "end" of a zodiacal sign to be approximately the first and last 5° respectively. In addition the figures show that this was

not a case of the regions' being exclusively "beginning", "middle" or "end" of a sign, as 'unclassified" (those where no qualifying adjective is used to the zodiacal sign) records can still refer to the first or last 5° of a sign.

The same results are represented in Figures 3.2a-d, which summarise the frequency of the three types of records ("beginning", unclassified or "end") across the zodiacal signs. The figures make it immediately clear that, as with the previous figures, "beginning" records are extremely common between 0° and 5°, and "end" records are extremely common between 25° and 30°. Unclassified records occur across the entire zodiacal sign at roughly the same frequency, with a slight trend towards the middle of the sign as we might expect.

The data are also summarized in Table 3.6, which shows the mean distances from the zodiacal sign boundary for each "beginning" and "end" record, and the standard deviations. For this table the longitude difference between the planet and the *nearest* zodiacal boundary was calculated; i.e. the longitude 0° into the zodiacal sign for "beginning" records, and the longitude 30° into the zodiacal sign for end records.

For each text, values are given for three different subsets of the data: all of the planets together; Mercury alone; and the four planets other then Mercury. The number of data points being considered in each case is also given. Mercury is analysed separately because its motion is particularly fast, making its records more prone to errors. For the other planets, the number of data points is too small for individual analysis to be worthwhile, particularly in the case of the small datasets of the Normal Star Almanacs and Almanacs.

The tables show an overall mean distance of between 3º and 4º into zodiacal signs for the beginning and end data, with a standard deviation of between 2º and 3º across the various types of text. This lends considerable further support to the suggestion that the "beginning" and "end" of a zodiacal sign were intended to correspond to about the first and last 5° of the sign. There is no evidence that the "beginning" and "end" regions were intended to be of different length.

As we would expect, the mean distance of Mercury into a sign and its standard deviation are both somewhat larger than for the other planets. Mercury can move through the 5° "beginning" or "end" region in only two or three days, and so an uncertainty of one day in the date of the record will have a noticeable effect on its position.

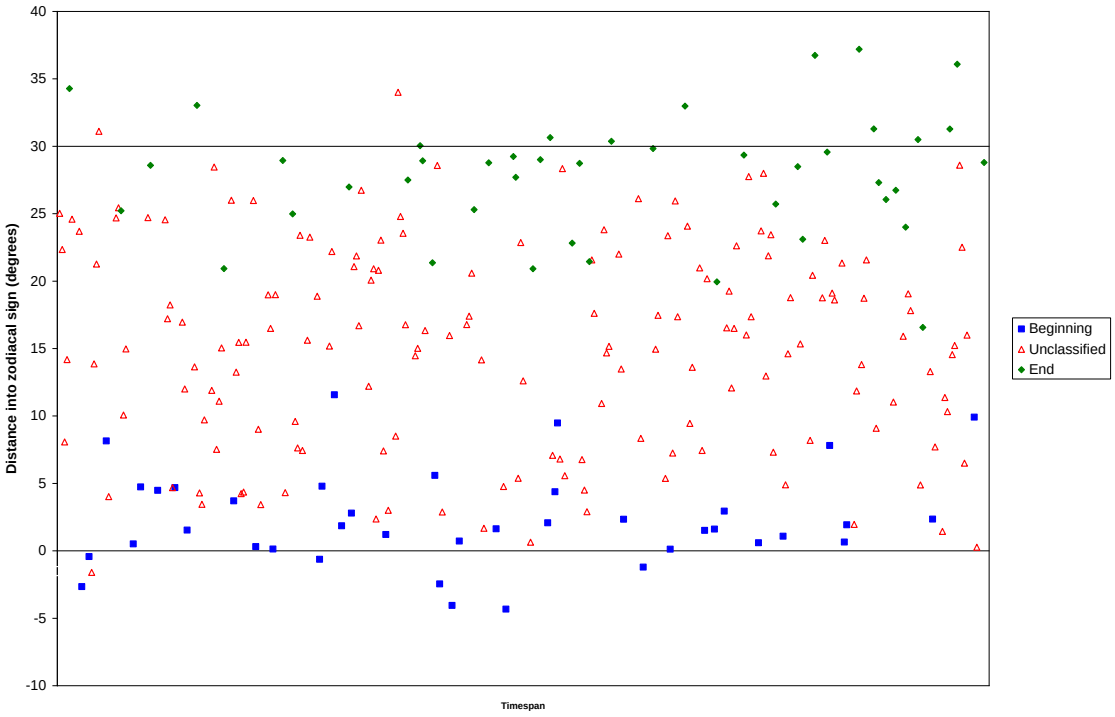

Figure 3.1a: The planet's distance into the zodiacal sign at the point of each dated Greek-letter phenomenon recorded in the Astronomical Diaries. The data are divided into three categories: records which specify the "beginning" of the zodiacal sign, records which specify the "end" of the zodiacal sign, and records which specify neither.

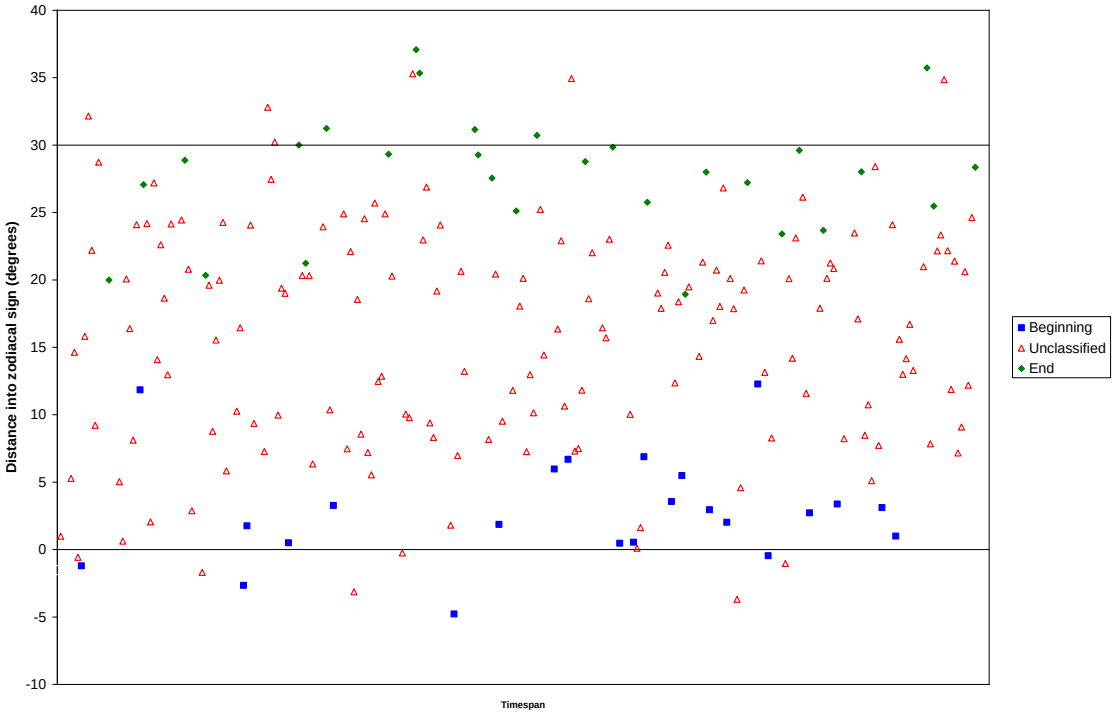

Figure 3.1b: As Figure 3.1a, for the Goal-Year Texts' records

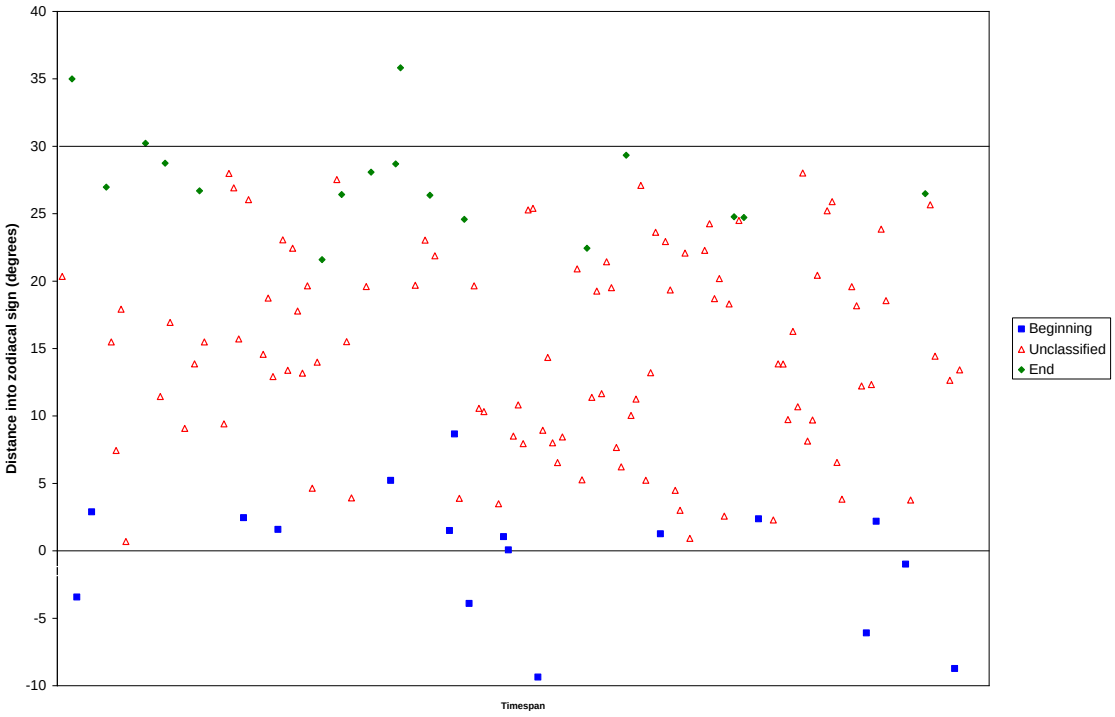

Figure 3.1c: As Figure 3.1a, for the Normal Star Almanacs' records

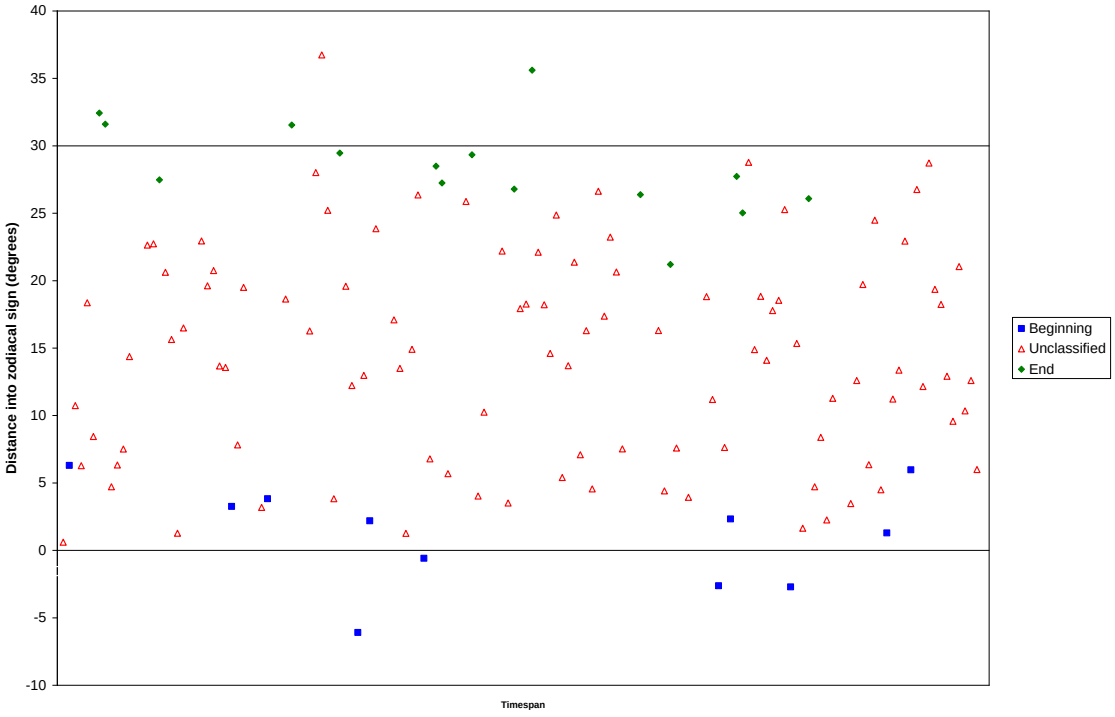

Figure 3.1d: As Figure 3.1a, for the Almanacs' records

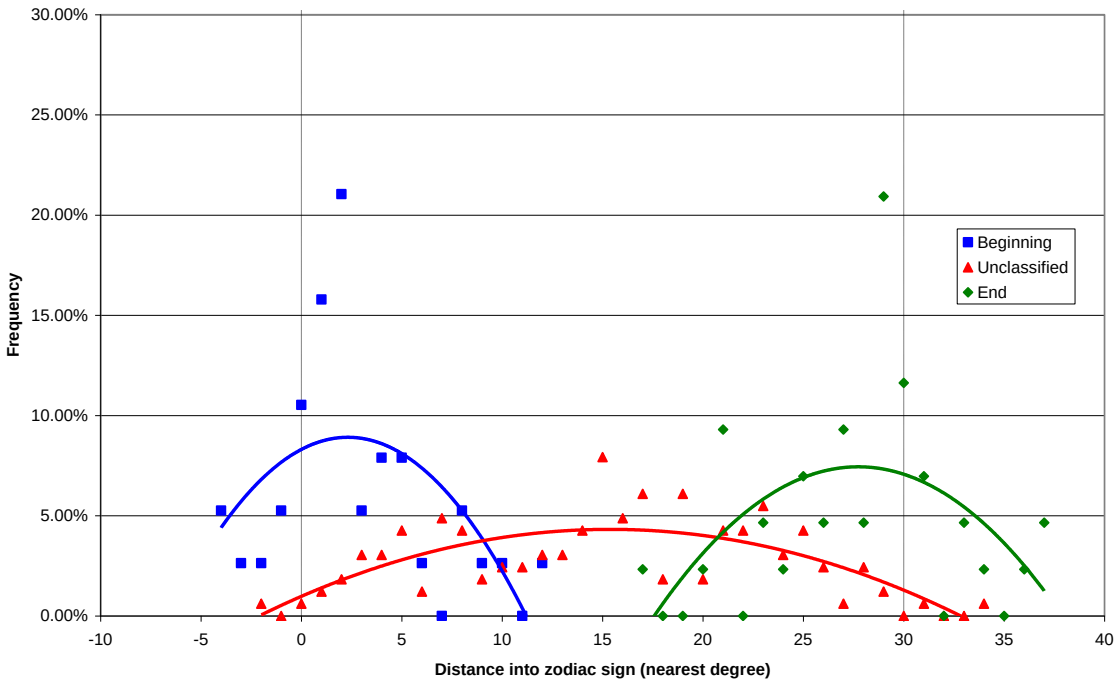

Figure 3.2a: the frequency of beginning/unclassified/end records across the zodiacal signs for observations from the Astronomical Diaries.

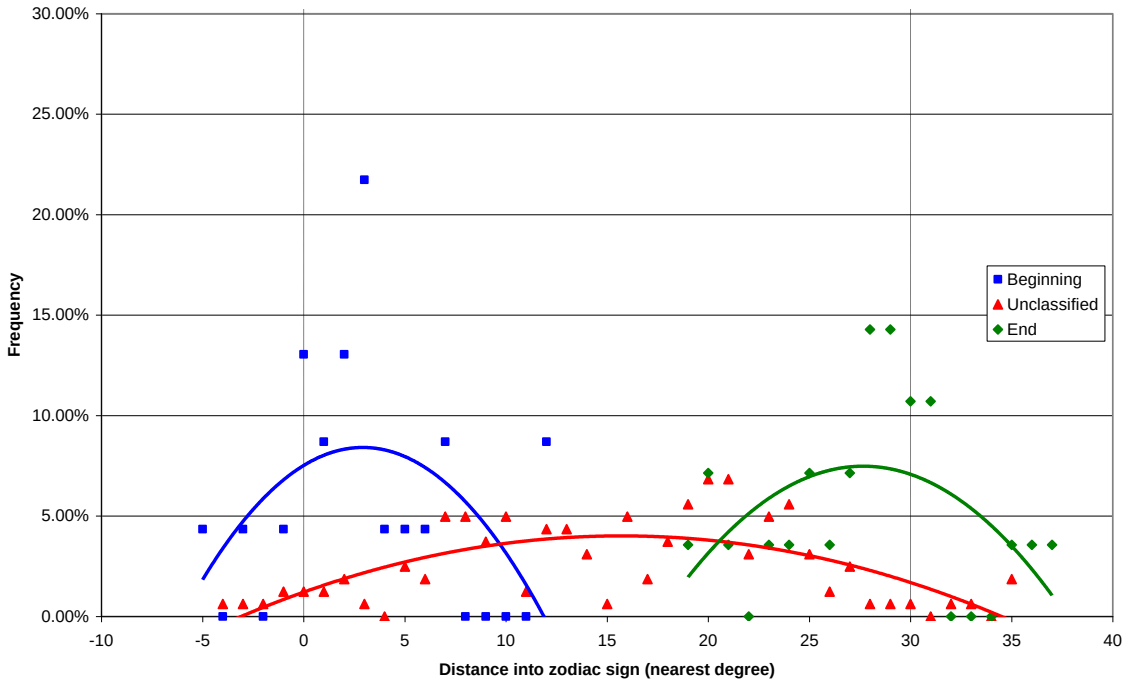

Figure 3.2b: as Figure 3.2a, for the Goal-Year Texts' observations

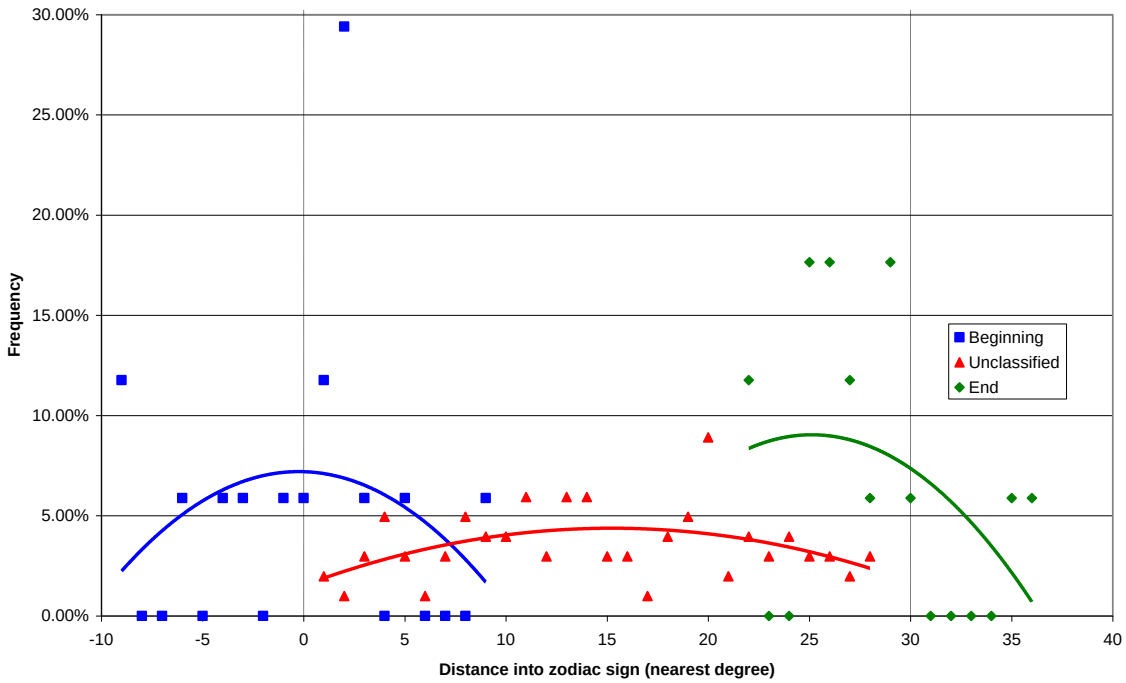

Figure 3.2c: as Figure 3.2a, for the Normal Star Almanacs' predictions

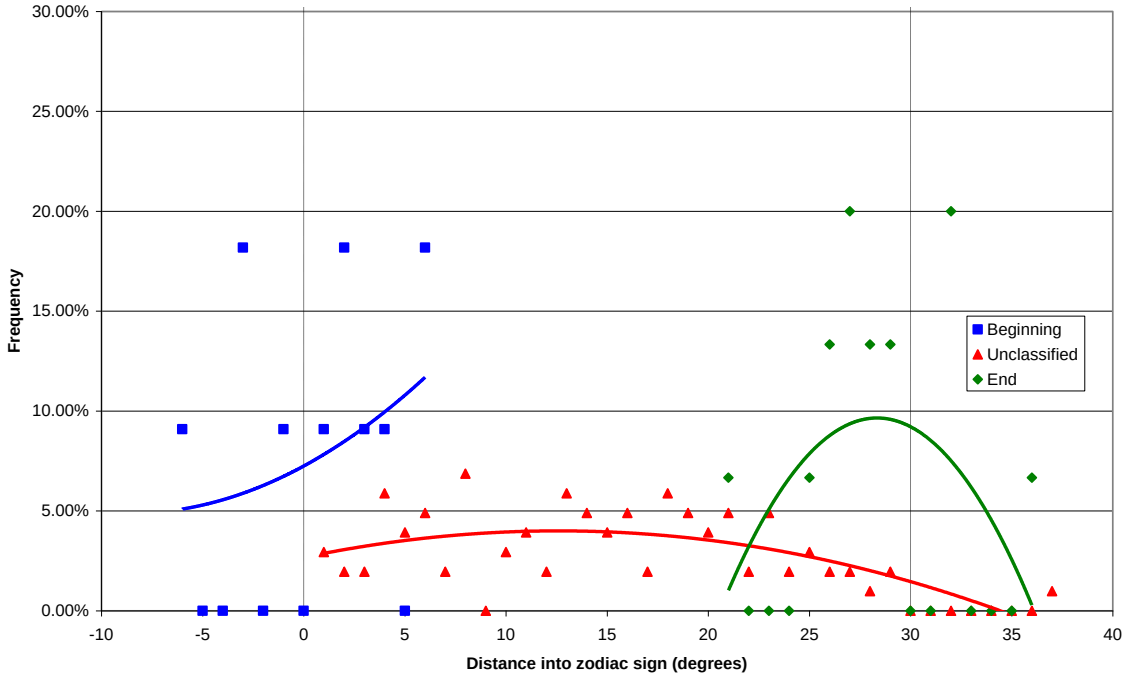

Figure 3.2d: as Figure 3.2a, for the Almanacs' predictions

Text type	Planet	Number of records	All 'beginning' and 'end' records		All 'beginning' records		All 'end' records	
			Mean distance (°)	Standard deviation (°)	Mean distance (°)	Standard deviation (°)	Mean distance (°)	Standard deviation (°)
Astronomical Diaries	All planets	81	3.556	3.062	3.161	2.723	3.847	3.260
	Mercury	39	4.502	3.628	4.007	3.532	4.846	3.733
	Other planets	42	2.678	2.109	2.758	2.094	2.698	2.181
Goal-Year Texts	All planets	51	3.629	3.263	3.597	3.253	3.657	3.331
	Mercury	26	4.043	3.553	3.811	3.360	4.227	3.806
	Other planets	25	3.077	2.938	3.382	3.277	2.773	2.666
Normal Star Almanacs	All planets	34	3.735	2.624	3.634	2.951	3.836	2.338
	Mercury	11	5.429	2.615	5.726	3.026	5.071	2.315
	Other planets	23	2.925	2.258	2.493	2.301	3.322	2.241
Almanacs	All planets	26	3.342	2.090	3.717	2.053	3.066	2.145
	Mercury	15	3.284	2.544	3.617	2.339	2.993	2.836
	Other planets	11	3.420	1.362	3.891	1.744	3.150	1.157

Table 3.6: Analysis of records of planetary positions in the 'beginning' or 'end' of a zodiacal sign

Lastly, there are a small number of lunar eclipse records that give the zodiacal sign in which the observed or predicted eclipse could be seen. (As previously established, the majority of eclipse records that give a position use the Normal Stars as reference points.) The few eclipse records which mention a position relative to the beginning or end of a zodiacal sign are summarized in Table 3.7. There are too few to analyse statistically but the corrected longitude of the start and end of each eclipse are in general agreement with the above estimate of the "beginning" or "end" region of the zodiacal signs.

Date	Eclipse location	Corrected longitude (°)	
		Start of eclipse	End of eclipse
–178 Jul 24	Predicted in the beginning of Aquarius	301.30	302.76
–170 Aug 23	Observed in the end of Aquarius	330.99	333.15
–105 Aug 25	Observed in the beginning of Pisces	330.68	332.38
–98 Apr 11	Observed in the end of Libra	202.16	204.34

Table 3.7: Details of lunar eclipse records which give the position of the Moon in the "beginning" or "end" of a zodiacal sign

Chapter 4

The effectiveness of the Goal-Year type planetary periods

4.1 Introduction

One question relating to Goal-Year astronomy which has raised relatively little discussion is why the Babylonian astronomers chose the particular planetary periods which were used in the Goal-Year Texts. This chapter will analyse the various planetary periods found in Late Babylonian astronomical texts to assess how effective they are compared with each other (and evaluate how exactly we can define "effective" in this context), and hopefully reach some understanding of why the compilers of the Seleucid Era texts settled on the particular Goal-Year periods that they chose.

It may be helpful to think of the recurrence relations for the planets in terms of their mean synodic periods. It is clear that periods across which planetary events recur closely will be found at the points where a planet's mean synodic period in days is very close to an integer number of mean solar years. For example, 46 mean solar years = 144.99 synodic periods of Mercury, suggesting that events for Mercury will recur closely after 46 years; similarly, 8 mean solar years = 5.005 synodic periods of Venus.[149] This provides an important starting-point for considering which planetary periods would in theory work well. However, one must bear in mind that the recurrence relations calculated in this way are relative to the mean solar year of ~365.24 days. While the length of the mean Babylonian year is of course extremely close to this number, any particular Babylonian year can only be a whole number of lunar months and therefore will be ~354 or ~384 days. The effect of the Babylonian year's variable length is analysed in Chapter 6.

4.2 The procedure texts

First we must examine where the planetary periods are found. The main source for these is, of course, the Goal-Year Texts, in which the same planetary periods were consistently used across 200 years. However, there are several other texts which refer to various other planetary periods being used to make Goal-Year type empirical predictions, particularly in the pre-Seleucid period.

For conciseness in this thesis, I refer to the texts from which the planetary periods are taken as "procedure texts". Note that I am only considering the texts which refer to periods for planetary events, rather than texts with ACT-type methods for calculating successive phenomena of a planet, say, or daily longitude/latitude changes.[150]

It is also important to note that, unlike the procedure texts in mathematical astronomy, the texts described here are *not* generally linked in any way and do not form any kind of coherent series. Indeed, most of them have been described by modern scholars as "unusual" or "atypical", for various reasons. The texts come from different points across the entire Late Babylonian Period, originate from different cities, and appear to have been

[149] with thanks to F. R. Stephenson for pointing these synodic periods out to me.
[150] See, for example, Atypical Text F in Neugebauer & Sachs (1967), and the texts discussed in Steele (2005), although tablet BM 40661 in the latter reference does also state Jupiter's 12-year period.

written for a variety of uses both astronomical and astrological. The only aspect that they are certain to have in common is that they contain some reference (or apparent reference) to a number of years over which a planet's motion or position will recur. The following sections will introduce the texts individually, in roughly chronological order, to give an impression of their contents, apparent uses, and approximate dates.

4.2.1 The Goal-Year Texts

As described in Chapter 2, the Goal-Year Texts contain excepts from Astronomical Diaries for particular years, with specific periods in mind. As a reminder, the planetary periods used in the creation of these texts are repeated below, along with the number of mean synodic periods covered by this period of years (calculated by F R. Stephenson):

Mercury's events	46 years	144.99 synodic periods
Venus' events	8 years	5.005 synodic periods
Mars' Greek-letter phenomena	79 years	36.995 synodic periods
Mars' Normal Star passages	47 years	22.01 synodic periods
Jupiter's Greek-letter phenomena	71 years	65.01 synodic periods
Jupiter's Normal Star passages	83 years	76.0006 synodic periods
Saturn's events	59 years	56.995 synodic periods

4.2.2 BM 92685 (DT 78)

This is an unusual astrological text, which contains omen clauses written entirely in numbers. Gadd's study of this text includes a transliteration of the last 11 lines of the tablet (Rev. lines 56' to 66'), which mention the planets and a list of years which may refer to planetary periods.[151] Lines 56' to 60' each mention one of the planets, in the conventional order found in the Goal-Year Texts (i.e. Jupiter, Venus, Mercury, Saturn, Mars). Lines 61' to 66' each contain a reference to a specific number of years (along with other, less-understood remarks) in the following order: 71, 60, 59, 8, 15, 12.

These years are not linked with any specific planet in the text but, as Gadd points out, 71, 59 and 8 years are surely references to the Goal-Year periods for, respectively, Jupiter, Saturn, and Venus.[152] He speculates on which planets the other periods may refer to, as well as querying why the above sequence of years contains six entries when only the five standard planets are mentioned in the text, and why the sequence of years visibly does *not* refer to the planets in the conventional order. However, he does not draw any firm conclusions.

There has been more recent speculation on what this sequence of years refers to. Brown believes that the sequence refers to planetary periods for, respectively, Jupiter (71 years); Mercury (60 years); Saturn (59 years); Venus (8 years); Mars (15 years); and Jupiter again (12 years).[153]

An alternative suggestion has recently been proposed by Britton, who interprets the numbers as planetary periods for, respectively, Jupiter (71 years); the Sun (interpreting the second numeral as "1" rather than Gadd's "60"); Jupiter [sic] (8 years; clearly Venus is intended); Mars (15 years); and Mercury (Britton suggesting that "12" in the text is a scribal

[151] Gadd (1967).
[152] Gadd (1967), p.61-62. See also Hunger (1969).
[153] Brown (2000), p. 194.

error for Mercury's elsewhere-attested period of 13 years).[154]

In other words, the three possible interpretations agree on the purpose of the numbers 71, 59, 8 and 15, and disagree on the numbers 60 (or 1) and 12 (or 13). Jupiter's 12-year period and Mercury's 13-year period are attested in other texts, making either interpretation equally plausible. In either case, it is interesting that DT 78 also appears to contain the only reference to a 15-year period for Mars and, if the former of the two interpretations is correct, it also represents the only reference to a 60-year period for Mercury. (See the summary in Table 4.2 later in this chapter.)

Gadd dates DT 78 securely to the late 7th century BC, based on a note on the tablet that it belonged to a group of tablets compiled for the son of King Ashurbanipal.[155] Brown interprets this note as referring to the King himself rather than his son, but otherwise agrees with Gadd by suggesting a date in "the period before 612 BC".[156] If these dates are correct, then the tablet therefore represents one of the earliest references to planetary periods. Of particular interest is the implication that at least some of the Goal-Year periods were known of so early in the period, roughly 400 years before the earliest extant Goal-Year Texts.

4.2.3 BM 45728

BM 45728 is a true procedure text, containing periods of recurrence (expressed in terms of number of years plus a date correction) for the Moon, Venus, Mercury, Mars, Saturn and Sirius. The text was described (and copied) in SSB I,[157] and more recently by Britton, who translates the text as well as summarising the periods and their corrections.[158] The lack of a period for Jupiter is puzzling, but as Britton's transcription shows, the beginning of the text is broken and this missing portion may well have referred to Jupiter.

Britton states that the text was "possibly written in the 2nd half of the 7th century",[159] and probably in Babylon based on mentions of the text's author on other tablets. As with DT 78, which dates to approximately the same period, we see very early mentions of the Goal-Year periods of 8 years for Venus and 59 years for Saturn. Here we also see the first mention of a 47-year period for Mars.

4.2.4 BM 33066 (LBAT **1477, Strassmeier Cambyses 400)

This tablet, described by Britton as a "unique proto-almanac",[160] contains records of Lunar Six events, planetary phenomena, planetary conjunctions with the Moon or another planet, and lunar eclipses for year 7 of Cambyses; i.e. year -522/-521. The section on planetary phenomena also refers to a few events in year 8 and (the non-existent) year 9 of Cambyses.

Hunger & Pingree suggested that the tablet was written in the "late fifth or early fourth century B.C.",[161] i.e. more than a century after the period covered by the records. However,

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154 Britton (2009), p.359.
155 Gadd (1967), p. 52.
156 Brown (2000), p. 193.
157 Kugler (1907), pp. 45-47.
158 Britton (2002), p. 59 and 61.
159 Britton (2002) p. 26. Despite a later published remark dating the text to the "first half of the sixth century" (Britton 2008, p. 19), he now maintains that the 7th century date is substantially more likely (personal communication).
160 Britton (2007b), p. 7.
161 Hunger & Pingree (1999), p. 175.

Britton now believes that it was actually written during the reign of Cambyses, with two main arguments in his favour. Firstly, new evidence of the sophistication of early Lunar Six prediction techniques has arisen since Hunger & Pingree's book was published, proving that the necessary techniques to predict the lunar data were available in the 6th century BC.[162] Secondly, the references to Cambyses year 9 would be erroneous for any later astronomers writing about this time period (as Cambyses died in the 8th year of his reign), but would simply be a natural extension of dates for a scribe writing during Cambyses' reign.

Britton's analysis of the records suggest that the most likely periods used to predict the planetary events were 6 years for Mercury; 56 years for Venus; 32 years for Mars; 71 years for Jupiter; 59 years for Saturn. The Goal-Year periods of 8 years for Venus and 47 years for Mars are also analysed but considered to not fit the records as well. This text, then, appears to be the only example of the use of a 32-year period for Mars.

4.2.5 BM 35402 (LBAT 1593)

This text is extremely unusual because of the exceptionally long planetary periods it suggests for Jupiter, Venus, Mars, Saturn and the Moon (but not Mercury) – periods of several hundred years in each case.[163] It was copied and discussed in SSB I by Kugler, who simply described it as "an astrological tablet".[164] Kugler shows how the long periods can be represented as simple multiples of other attested periods. Note that Reiner has also translated this text and discussed its astrological content, but she does not include the planetary periods section which we are interested in here because of its previous study by Kugler.[165] The date of this text is unknown, although Sachs classifies it in LBAT under "Late Astrology".

4.2.6 BM 34560 (LBAT 1515)

The exact categorisation of this text's contents remains a mystery, as does its date. Sachs describes it in LBAT as a text of planetary periods, and categorises it as intermediate astronomy, i.e. "later than MÚL.APIN and earlier than ACT".[166] More recently, Steele refers to it as a procedure text, "probably a late text".[167] The most recent speculation is that LBAT 1515, rather than being a procedure text for the Goal-Year periods, is in fact an attempt to use the Goal-Year periods to analyse relative planetary and solar motion.[168] Whatever the methods were behind this obviously very intriguing text, it is clear that it contains references to the well-established planetary periods for Jupiter, Venus, Mercury and Saturn; hence its inclusion in this list.

4.2.7 AO 6455 (TU 11)

This text is a collection of rules relating to planetary and lunar predictions, from Uruk. The majority of the contents are concerned with rules for astrology and for predicting lunar events; the lunar theories have been well analysed in Brack-Bernsen & Hunger's recent

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[162] For example, see Brack-Bernsen (1999a).
[163] Neugebauer & Sachs (1967), p. 206, also lists BM 40113 as a duplicate of these planetary periods.
[164] Kugler (1907), p. 48-53.
[165] Reiner (2000).
[166] Sachs (1955), p. xxxv.
[167] Steele (2009, forthcoming)
[168] J. M. Steele, personal communication.

translation and interpretation of the text.[169] Only one brief section of the text refers to the calculation of planetary periods, a section translated by Brack-Bernsen & Hunger as follows:

> "In order for you to calculate (lit., "make") rain and flood: 72 of Jupiter; 64, variant: 16, of Venus; 46, variant: 13, of Mercury; 59 of Saturn; 79, variant, 47, of Mars."
> - AO 6455, Rev. 23 (Brack-Bernsen & Hunger (2002), p.16)

This suggests an attempt to associate recurrence of high river levels with planetary positions or events, which is slightly outside the scope of this work. Here, only the recurrence of the planetary events across these periods will be checked.[170] A few other sections of TU 11 refer to one or more of the planets; the meaning of these sections is more obscure, although they do not appear to be predicting planetary periods.

Brack-Bernsen and Hunger date TU 11 to the late 3rd century B.C., based on the scribe's name in the colophon. However, Brack-Bernsen has argued that the rules it contains do not necessarily come from that date, but that they are a collection of old and new rules from much earlier in the period.[171] This means that it is impossible to suggest when the text's planetary periods might have been in use; it could have been at any point of the Late Babylonian Period (up to the early Seleucid Era), or even earlier. Brack-Bernsen concludes that simply "How far back in time these rules were known, we do not know."[172]

4.2.8 BM 41004 (Atypical Text E[173])

This is an interesting procedure text, containing: dates and procedures for relating lunar latitude and motion by Normal Stars, possibly a short (damaged) section of instructions concerning planetary conjunctions, and procedures for calculating planetary motion by Normal Stars (giving planetary periods in the form of a number of years plus a date or longitude correction). The periods and corrections are summarised, and have been thoroughly analysed, by Neugebauer & Sachs.[174] More recently, Brack-Bernsen and Hunger have published a translation of this text.[175]

The exact date of Atypical Text E is not known, and the authors do not suggest one, although Neugebauer & Sachs do state that the (lunar) "longitudes refer to a period of about 500 B.C.".[176] The tablet's colophon reads: "Tablet of Marduk-šāpik-zēri, son of Bēl-apla-idinna, descendant of Mušēzib, [written by] the hand of Iddin-Bēl, son of Marduk-šāpik-[zeri, descendan]t of Mušēzib";[177] the same names occur in the colophon to Atypical Text F,[178] which is also undated. Robson discusses this family, whose names occur on the colophons of several important texts.[179] Based on the fact that one of these important texts is a copy of *Enūma Anu Enlil* I, apparently written by Marduk-šāpik-zēri in SE 142,[180] it

169 Brack-Bernsen & Hunger (2002).
170 For further discussion of related matters, see for example Hunger (1976) for a study of TU11 and other texts which connect planetary motion and weather events, and Slotsky (1997) for an analysis of river level data from the Diaries.
171 Brack-Bernsen (2002).
172 Brack-Bernsen (1999a), p. 175.
173 Named following its inclusion in Neugebauer & Sachs (1967).
174 Neugebauer & Sachs (1967), pp 200-208.
175 Brack-Bernsen & Hunger (2006).
176 Neugebauer & Sachs (1967), p. 204.
177 Neugebauer & Sachs (1967), p. 207.
178 Neugebauer & Sachs (1967), p. 208-210.
179 Robson (2008), pp 220-227.
180 Verderame (2002), p. 49.

seems reasonable to estimate that Atypical Text E is also from the early 2nd century BC.

4.2.9 The Astronomical Cuneiform Texts

For completeness, the planetary periods from the ACT procedure texts are also included here. As described in Chapter 1, these procedure texts mostly contain instructions for calculating longitudes and other phenomena of planetary motion; here we are interested in the relatively few which also list the number of years between a certain number of a planet's phenomena. These are tabulated below:

Planet	Period (in Babylonian years)	Period is found in *ACT* numbers
Mercury	46	800
	355	816
Venus	8	815
Mars	47	811
	79	811
	264	811, 811a
Jupiter	12	811, 813, 814
	71	812, 813, 814
	83	812, 813
	95	812
	166	813
	261	812
	427	812, 813, 814
Saturn	265	801, 802, 819c

Table 4.1: a summary of the planetary periods referred to in the Astronomical Cuneiform Texts.

The dates in which individual procedure texts were written are not generally known. The *ACT* planetary ephemerides date from at least SE 4 to 303, and so it seems reasonable to estimate based on this that an *ACT* procedure text could date from any part of the Seleucid Era.

4.2.10 A summary of the planetary periods from the procedure texts

Table 4.2 on the following page is a summary of the above sections, collecting together and giving details of the periods attested in the various texts for each of the planets.[181]

[181] This table is adapted from Steele (2009, forthcoming).

Text	Mercury	Venus	Mars	Jupiter	Saturn
Goal-Year Texts	46 years	8 years	79 years (phenomena) 47 years (passages)	71 years (phenomena) 83 years (passages)	59 years
BM 92685 (DT 78)	60 years? 13 years?	8 years	15 years	71 years 12 years?	59 years
BM 45728	6yr + 10 days	8yr - 4 days	47yr + 12 days		59 years
BM 33066 (Cambyses text)	6 years	8 or 56 years	32 or 47 years	71 years	59 years
BM 35402 (LBAT 1593)		6400 years	284 years	344 years	560 years
BM 34560 (LBAT 1515)	46 years	8yr - 4 days		71yr - 5° 83yr - 7 days 12yr + 6°	59yr - 5 days
TU 11	13 years 46 years	16 years 64 years	79 years 47 years	72 years	59 years
BM 41004 (Atypical Text E)	13yr - 3 days 46yr - 1 day 125yr	8yr - 4 days 16yr - 2 days 48 yr + 2 days 64yr + 1 or 2 days 8yr - 4° 16yr - 2°	32yr - 5 days 47yr + 4 days 64yr + 4 days 126yr	12yr - 1 month 12yr + 5° 71yr 83yr - 7 days	59yr - 6 days 30yr + 9 days 30yr + 7°;20 147yr
ACT	46 years 355 years	8 years	47yr … 79yr … 284 years	12yr + 4°;10 71yr - 5° (slow arc) 71yr - 6° (fast arc) 83yr - 1° 95yr + 4° 166yr? 261yr + 4° 427 years	265 years

Table 4.2: a summary of attested planetary periods (and corrections to date or longitude when given) from all of the procedure texts

In short, the following periods of Babylonian years are attested in at least one text:

Mercury	6, 13, 46, 60, 125, 355 years
Venus	8, 16, 48, 56, 64, 6400 years
Mars	15, 32, 47, 64, 79, 126, 284 years
Jupiter	12, 71, 72, 83, 95, 166, 261, 344, 427 years
Saturn	30, 59, 147, 265, 560 years

Venus' 6400 year period is not considered further here because it is outstandingly infeasible that the period was ever used in practice, particularly since the Late Babylonian Period was only around 800 years long. Note that some of the texts specify whether the period applies to Greek-letter phenomena or to Normal Star passages, but many of them do not. Therefore, each of these periods will be checked using both phenomena and passages. Note also that, while Table 4.2 includes all the attested periods and their corrections to dates[182] or longitudes, only the date corrections are analysed in this chapter and not the mathematical longitude changes.

4.3 How can we define how effective a planetary period is?

One might reasonably assume that the Babylonian astronomers chose the periods which worked the "best" for their own calculations – but how can we define what criteria might have led to this? Below I outline a few criteria which I believe it would have been necessary to take into account. By assessing how effective each of the various attested periods is – in other words, how well each period predicts events when considered against all of these criteria together – this will lead towards a better understanding of how the Babylonian astronomers settled on their chosen Goal-Year Text planetary periods.

We can infer several criteria which could be used to assess a period's usability by thinking about how the Babylonian astronomers would have used the planetary periods to make predictions.[183] Here are outlined five such criteria:

i. How consistent the period is for predicting dates of events. As we have seen from Table 4.2, the period does not have to be an exact number of Babylonian years. However, there should be consistency about what specific date correction is necessary. For example, when testing our hypothetical period of Y years - 4 days, we would expect that the majority of events would recur with a date close to 4 days earlier in the year Y years later. If instead we found that the *observed* date differences for equivalent events Y years apart varied apparently randomly between, say, ±30 days, then we could say that this would not be a very accurate period.

   In addition, different events will have a different tolerance regarding how accurate the date correction needs to be. For example, Mercury moves particularly fast (on average about 1° of longitude a day) and so a period used to predict its Normal Star passages would need to be very accurate and consistent in predicting the right day, because even one day later Mercury will have moved a substantial distance away from the star. On the other hand, Saturn is extremely slow-moving and will often barely seem to move for a month or more around a stationary point. This makes it a lot more difficult to decide, both for the Babylonian astronomers and for modern readers attempting to assess their methods, on exactly which day the stationary point should be recorded. Nevertheless, it does mean that there is more flexibility about how closely the date correction predicts the "true" date of the stationary point.

[182] From here on the number of days by which a planetary period differs from a full number of Babylonian years will be referred to as a *date correction*. For example, for a hypothetical attested period of Y years - 4 days, the date correction would be -4 days.

[183] Again, note that this is *not* drawing any direct conclusions about how the Babylonian astronomers chose which periods to use, or their thought processes. These criteria are just some that a modern observer might use to test whether predictions made using Babylonian Goal-Year methods gave an "accurate" result or not (and determine how we might define its accuracy).

ii. How consistent the period is for predicting planet-Normal Star distances at the time of a Normal Star passage. None of the procedure texts refer to any correction for these distances, so it seems most likely that the Babylonian astronomers did not expect to apply any corrections to the distance measurements when making predictions. (See Chapter 5 for further discussion of this.) If this is the case, then it is necessary to check how the latitude difference between the planet and the star changes after the planetary period has passed, allowing for precession.[184]

iii. How long the period is: assuming a period is accurate enough, a shorter period is preferable to a longer one. This is simply because a shorter period means it is much quicker to turn observed events into predictions for future years. Shorter periods can also be deduced sooner and date corrections can be improved more quickly if future observations do not quite agree with predictions.

This point is less important than i) and ii), in part because we assume that the Babylonian astronomers had a good archive of previous Diaries available. So it would be possible to copy out all observations relating to one planet for many decades and use this to deduce patterns in its motion; indeed, it is very likely that this is one purpose of some of the texts found in *ADART* Vol. V. Equally, some of the longer planetary periods are formed by combining multiples of shorter ones[185] and so it would not be necessary to have, eg, 400 years of Diary observations before a 400-year planetary period could be discovered. However, it would of course still take a very long time to *test* a period of 400 years observationally.

iv. What date correction is needed: all other things being equal, a planetary period which is an exact number of Babylonian years long, or only needs a very small date correction, will be more convenient to use than one which requires a larger number of days adding to or subtracting from the date of each predicted event.

v. If possible, a planetary period which works well for predicting both Greek-letter phenomena and Normal Star passages would be more convenient than using a separate period for each type of event.

Clearly, points i) and ii) are the most important – if the suggested date correction only predicts the right date a low percentage of the time, then how easy the period is to use, as points iii) to v) assess, is much less significant.

The following sections assess these points with the use of theoretical event data taken from Roughton's tables.[186] For each planetary period, a number of calculated dates of Greek-letter phenomena and Normal Star passages were compared with the dates of the equivalent events a planetary period later. For Normal Star passages, the latitudes of the star and the planet at the time of each event were also compared. The number of records

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[184] As stated in Chapter 3 and Jones (2004), the Babylonians' planet-star distance measurements were not purely a latitude difference, but instead would have been a function of both planetary latitude and longitude. Nevertheless it is still appropriate to check the latitude difference in this case: we know that the longitude will be approximately the same for both events because the planet is moving past the same Normal Star; therefore, the change in latitude will provide the best indication of whether the planet-star distance has changed.

[185] For example, Neugebauer & Sachs (1967), p.207 shows how this could have been done using the periods in Atypical Text E. One example for Mercury: the text gives periods of 13year - 3 days, 46 years - 1 day and 125 years exactly. 125years can be made from 3x46 - 13 = 125; and 3x(-1) - (-3) = 0.

[186] Roughton (2002); as before, see §1.4.3.

used for each analysis varied: the records spanned at least a complete Goal-Year period for each planet. Normal Star passages that took place when the planet was in a period of invisibility from Babylon were removed from the analysis.

The tables and figures in the following sections summarise the results of this analysis, showing the "average" date correction for each period, in terms of both the mean and the modal theoretical date correction. Including both of these date corrections is useful to give a fuller assessment of how well the period worked: in practice, the further apart the mean and the modal corrections are, the more skewed the set of calculated date corrections is, meaning that the period is less likely to be a good fit. Equally, since we do not know exactly what the methods used by the Babylonian astronomers would have used to determine the date correction for a planetary period, it is best practice to consider a range of possibilities.

This does not imply that the Babylonians literally used the modern statistical concepts of a dataset's mean or mode in their astronomical predictions. It is important not to forget that these terms belong to modern statistics rather than Babylonian astronomy, and one must be careful to avoid ascribing modern terminology and methods to ancient scientists. However, one may be tempted to speculate that "inspection of a planet's excerpted observational records to determine the most common date difference" would be a method very much in keeping with what else we know of Goal-Year methods of prediction.[187] Determining a date correction using this process would produce a result extremely similar to the modal value of a modern dataset; it would, crucially, be anachronistic to *call* their result the "mode".

The tables in the following sections also show what percentage of the theoretical date differences fall within ±1 day[188] and ±3 days either side of each theoretical date correction. As point i) in this section discussed, we might expect an effective planetary period for an inferior planet to have a high percentage of the events recur within ±1 day of the date correction, and an effective period for a superior planet to have a high percentage of events recur within ±3 days of the date correction. All of the calculated theoretical dates are given to the nearest day, since Babylonian observations are only generally recorded to the nearest day.[189]
Note that in the following tables the periods will be given in lunar months as well as Babylonian years. This is because (as we shall see in Chapter 6) the Babylonian system of intercalary months means that a period of Babylonian years does not always cover the same length of time when measured in lunar months. Since the periods of the planets' motions will naturally *not* vary with the Babylonian calendar, it reduces confusion to record the periods in units of lunar months (± a date correction when necessary). A Babylonian year is always a whole number of lunar months long and so the date correction will not be any different for a period quoted in lunar months or in Babylonian years.

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[187] For example, text BM 36823 (*ADART* Vol. V, No. 54) contains Jupiter records at 12-year intervals arranged in columns – see Steele (2009) – which would be a useful way of presenting the records if an astronomer wished to examine the differences in date between equivalent events 12 years apart.
[188] I.e. the day itself, plus one day earlier or later.
[189] It is true that the usual format of a Normal Star passage says whether it was observed in the "first" or "last part of the night". However, note that this says absolutely nothing about the planets' *true* time of passage, i.e. the calculated exact point at which it passes the star (however that may have been defined). The "first/last part of the night" simply recorded whether the planet was above the horizon earlier or later in the night at the time of passage, as discussed in §1.3.5.4. In my opinion we cannot be completely certain that the Babylonian astronomers would have observed an event on the exact day suggested by rounding off a modern calculated date, rather than one day earlier or later.

4.4 How well do the planetary periods predict dates of Greek-letter phenomena?

Table 4.3a summarises the theoretical date corrections for Mercury's Greek-letter phenomena. Several of these periods work extremely effectively, with almost all of the events occurring within 1 day of the suggested date correction after 13, 46, 125 or 355 years. Out of these four periods, we can speculate (using the five criteria outlined in §4.3) that the 46-year Goal-Year period was chosen because it is accurate, conveniently short, and needs very little correction to the dates of phenomena.

Table 4.3b summarises the theoretical date corrections for Venus' Greek-letter phenomena. From the results one would suggest that the 8-year Goal-Year period was chosen because it is conveniently short and also very accurate, with the longer periods showing no increase in accuracy.

Table 4.3c summarises the theoretical date corrections for Mars' Greek-letter phenomena. It shows that Mars' phenomena do not recur as precisely as Mercury's or Venus'. Clearly most of the shorter attested periods for Mars are somewhat imprecise: compared with Mercury and Venus, where the most common date correction would be within a few days of all of the records, for Mars there is a wider range of date differences. 79 years and 284 years are the only periods which recur reasonably accurately, and 284 is inconveniently long which makes the 79-year Goal-Year period an obvious choice.

Table 4.3d summarises the theoretical date corrections for Jupiter's Greek-letter phenomena. Unlike Mars, Jupiter's events recur very closely over nearly all of the periods suggested (except 72 years), and so in terms of accuracy any of the periods could have been chosen as a Goal-Year period. Using the criteria from §4.3, we could speculate that the 71-year Goal-Year period was chosen because, as with Mercury, it fulfils all the criteria of being very accurate, conveniently short, and needing very little correction to the dates of phenomena.

Table 4.3e summarises the theoretical date corrections for Saturn's Greek-letter phenomena. As with Jupiter, most of the periods suggested are extremely accurate. Using our criteria to eliminate the periods over 100 years, there does not seem to be much to choose between 30 and 59 years in terms of accuracy. The 59-year Goal-Year period is slightly more accurate when considering how many phenomena dates recur to within ±1 day of the date correction, but as we have previously established this is less significant because of Saturn's slow motion, and the difficulty involved with determining the correct date of stationary points.

Period		Mean date correction			Modal date correction		
Babylonian years	Lunar months	Date correction	Percentage within ±1 day	Percentage within ±3 days	Date correction	Percentage within ±1 day	Percentage within ±3 days
6	74	+16	77	95	+16	77	95
13	161	-3	96	99	-3	96	99
46	569	-0	96	100	-1	99	100
60	742	-10	63	94	-9	65	94
125	1546	+2	99	100	+3	98	100
355	4391	+1	90	97	+1	90	97

Table 4.3a: a summary of the date corrections to Mercury's Greek-letter phenomena dates, across each of the planetary periods attested in the procedure texts.

Period		Mean date correction			Modal date correction		
Babylonian years	Lunar months	Date correction	Percentage within ±1 day	Percentage within ±3 days	Date correction	Percentage within ±1 day	Percentage within ±3 days
8	99	-4	98	100	-3	99	100
16	198	-8	98	100	-8	98	100
48	593	+6	67	95	+7	75	98
56	692	+3	70	91	+3	70	91
64	791	-1	69	89	-1	69	89

Table 4.3b: as Table 4.3a, for Venus' Greek-letter phenomena

Period		Mean date correction			Modal date correction		
Babylonian years	Lunar months	Date correction	Percentage within ±1 day	Percentage within ±3 days	Date correction	Percentage within ±1 day	Percentage within ±3 days
15	185	-3	10	26	+2	38	59
32	396	+5	19	63	+2	51	70
47	581	+2	29	81	+4	57	72
64	792	+10	9	23	+4	32	57
79	977	+7	87	97	+6	83	96
126	1558	+8	32	89	+10	63	79
284	3513	-7	87	99	-7	87	99

Table 4.3c: as Table 4.3a, for Mars' Greek-letter phenomena

Period		Mean date correction			Modal date correction		
Babylonian years	Lunar months	Date correction	Percentage within ±1 day	Percentage within ±3 days	Date correction	Percentage within ±1 day	Percentage within ±3 days
12	148	+17	91	100	+18	100	100
71	878	+0	97	100	+1	94	100
72	891	+15	36	88	+13	45	65
83	1026	+17	100	100	+17	100	100
95	1175	+5	100	100	+5	100	100
166	2053	+5	100	100	+5	100	100
261	3228	+11	99	100	+10	99	100
344	4255	-1	100	100	-1	100	100
427	5281	+16	100	100	+16	100	100

Table 4.3d: as Table 4.3a, for Jupiter's Greek-letter phenomena

Period		Mean date correction			Modal date correction		
Babylonian years	Lunar months	Date correction	Percentage within ±1 day	Percentage within ±3 days	Date correction	Percentage within ±1 day	Percentage within ±3 days
30	371	+9	96	100	+9	96	100
59	730	-6	99	100	-6	99	100
147	1818	+3	100	100	+3	100	100
265	3278	-8	97	100	-7	100	100
560	6926	+22	80	100	+21	89	100

Table 4.3e: as Table 4.3a, for Saturn's Greek-letter phenomena

4.5 How well do the planetary periods predict dates of Normal Star passages?

In general, planetary periods do not recur as accurately for Normal Star passages as they do for Greek-letter phenomena. This is particularly apparent around stationary points: if a stationary point does not happen at close to the same longitude in the observation year and the year one planetary period later – even in a period which is otherwise very accurate – the dates of Normal Star passages will vary greatly from each other around the stationary points. (This will be illustrated and discussed further in Chapter 5.)

Table 4.4a summarises the theoretical date corrections for Mercury's Normal Star passages. Again, it is clear that the 46-year Goal-Year period is the most accurate overall, being conveniently short and needing very little correction to passage dates.

Table 4.4b summarises the theoretical date corrections for Venus' Normal Star passages. Again, we find the same situation as with Venus' phenomena dates: the 8-year Goal-Year period is the most accurate, with the longer periods showing no increase in accuracy. Once again, this period is also conveniently short and needs very little correction to passage dates, making it the obvious choice.

Table 4.4c summarises the theoretical date corrections for Mars' Normal Star passages. As with the phenomena dates, Mars' passage dates do not recur as precisely as Mercury's or Venus'. In terms of the accuracy of the date corrections to within ±3 days, there is little difference between that of Mars' Goal-Year period for Normal Star passages, 47 years, and its 79-year phenomena period. (Again, 284 years is slightly more accurate but is inconveniently long.) Since the date correction for the 79 year period (+3 days) is more convenient than the 47 year period (+14 or 15 days), it remains uncertain why the Babylonian astronomers chose to use 47 years in the Goal-Year Texts rather than using the equally accurate 79-year period for both types of event.

Table 4.4d summarises the theoretical date corrections for Jupiter's Normal Star passages. Note that the 72-year period from text TU11 is not included on the table because it literally does not work at all (i.e., the date corrections would be a year long).

Unlike Mars, in this case it is immediately clear why different periods were used for Jupiter's phenomena and passages. Most of the suggested periods are not very accurate at all, and the 71-year period which was used for phenomena would not be as good a choice here. The most accurate period for Jupiter's Normal Star passages, apart from the extremely long ones, is certainly the 83-year Goal-Year period. Thus it seems quite logical that different periods were used for the two types of event.

Table 4.4e summarises the theoretical date corrections for Saturn's Normal Star passages. Note that the 30-year period from Atypical Text E is not included on this table because it does not work for Normal Star passages at all.

None of the suggested periods is particularly accurate for predicting passages. However, of the options, the 59-year Goal-Year period is clearly preferable in terms of accuracy and length of period, so it makes sense that it was used.

Period		Mean date correction			Modal date correction		
Babylonian years	Lunar months	Date correction	Percentage within ±1 day	Percentage within ±3 days	Date correction	Percentage within ±1 day	Percentage within ±3 days
6	74	+8	33	90	+10	69	83
13	161	-5	87	96	-5	87	96
46	569	-1	99	100	-1	99	100
60	742	-4	12	33	-1	55	71
125	1546	+3	93	98	+4	96	99
355	4391	-0	93	95	-0	93	95

Table 4.4a: a summary of the date corrections to Mercury's Normal Star passage dates, across each of the planetary periods attested in the procedure texts.

Period		Mean date correction			Modal date correction		
Babylonian years	Lunar months	Date correction	Percentage within ±1 day	Percentage within ±3 days	Date correction	Percentage within ±1 day	Percentage within ±3 days
8	99	-2	88	97	-1	92	97
16	198	-3	92	96	-4	86	94
48	593	+19	83	90	+19	83	90
56	693	-12	79	90	-13	78	87
64	791	+16	63	92	+15	82	89

Table 4.4b: as Table 4.4a, for Venus' Normal Star passages

Period		Mean date correction			Modal date correction		
Babylonian years	Lunar months	Date correction	Percentage within ±1 day	Percentage within ±3 days	Date correction	Percentage within ±1 day	Percentage within ±3 days
15	186	-2	16	46	-4	57	74
32	395	+18	50	87	+20	62	81
47	581	+15	60	87	+14	76	86
64	791	+6	20	69	+9	59	75
79	977	+3	86	90	+3	86	90
126	1559	-12	78	87	-12	78	87
284	3513	-6	89	97	-6	89	97

Table 4.4c: as Table 4.4a, for Mars' Normal Star passages

Period		Mean date correction			Modal date correction		
Babylonian years	Lunar months	Date correction	Percentage within ±1 day	Percentage within ±3 days	Date correction	Percentage within ±1 day	Percentage within ±3 days
12	148	-1	0	1	+3	26	42
71	879	-9	0	0	-3	30	44
83	1027	-9	7	55	-7	55	67
95	1174	+23	0	1	+18	35	50
166	2053	+12	0	22	+15	40	57
261	3228	+6	2	43	+3	53	64
344	4255	-3	37	66	-4	56	69
427	5281	+17	65	89	+17	65	89

Table 4.4d: as Table 4.4a, for Jupiter's Normal Star passages

Period		Mean date correction			Modal date correction		
Babylonian years	Lunar months	Date correction	Percentage within ±1 day	Percentage within ±3 days	Date correction	Percentage within ±1 day	Percentage within ±3 days
59	730	-10	0	5	-15	32	52
147	1819	-7	0	0	+9	13	30
265	3278	-1	0	0	+16	11	24
560	6926	+8	3	9	+4	16	33

Table 4.4e: as Table 4.4a, for Saturn's Normal Star passages

4.6 How well do the planetary periods predict planet-Normal Star distances?

As explained above, the accuracy of dates is not the only factor concerning Normal Star passage predictions. As well as a recurrence of longitude, an effective planetary period needs to be one over which the planet's latitude also recurs. Otherwise, accurate predictions of planet-Normal Star distances will be impossible.

The following figures show, for each period, how much the planet-star latitude difference changes for occurrences of the same passage one period apart.[190] On each histogram, the black column shows the Goal-Year Text period.

The latitude differences are shown in terms of fingers, the smallest Babylonian unit of astronomical distance as outlined in Chapter 1. The frequency of record comparisons which show a latitude change of less than 1 finger, a change of between 1 and 2 fingers, etc, are shown. In these figures the most important test of how well a period works is the percentage of records with a latitude change of less than 1 finger: since the finger is the smallest unit used by the Babylonian astronomers, only the records in this category would *not* predict an inaccurate measurement for the same event a planetary period later.[191]

Figure 4.1a summarises the latitude differences for Mercury's Normal Star passages. It shows that the 46-year Goal-Year period is unambiguously the most accurate in terms of latitude recurrence.
Figure 4.1b summarises the latitude differences for Venus' Normal Star passages. As with Mercury, the latitudes recur most accurately across the 8-year Goal-Year period

Figure 4.1c summarises the latitude differences for Mars' Normal Star passages. In this case it is odd that the 47-year Goal-Year period is *not* the period across which the latitudes recur most accurately. The 79-year period used for dates of Greek-letter phenomena would again have been a better fit, and it remains a mystery why this period was not also used for Normal Star passages.

Figure 4.1d summarises the latitude differences for Jupiter's Normal Star passages. Jupiter's latitudes tend to recur very accurately for almost all of the suggested periods, and the 83-year Goal-Year period is by far the best of the shorter periods (i.e. those under 100 years long). Note that the 71-year Greek-letter phenomena period is significantly the worst in terms of latitude recurrence, demonstrating again why the Babylonian astronomers used two different periods for predicting Jupiter's motion.

[190] Allowing for precession, as explained earlier.
[191] In reality, this criterion is almost certainly too strict. As Jones (2004) showed, larger planet-star distances were not recorded to an accuracy of a finger and a measurement of "4 cubits" could well refer to a range of distances between 3 ½ and 4 ½ cubits. Therefore, not *all* of the records in the figures with a latitude difference of even several fingers would necessarily result in an inaccurate prediction of a planet-star distance.

Figure 4.1e summarises the latitude differences for Saturn's Normal Star passages. As with Jupiter, all of the periods tend to show a close recurrence of latitude; but the 59-year Goal-Year period is clearly the best, with almost all of the events being at the same latitude to within 1 finger, and none showing a latitude difference of more than 2 fingers.

It is likely that this explains why 59 years was used for Saturn's Greek-letter phenomena as well. As discussed above, 30 years and 59 years were equally effective periods for Saturn's phenomena, but for Normal Star passage predictions the 30-year period is not very effective at all, and so the 59-year period is clearly superior.

In summary, this section has demonstrated how the various planetary periods compare with each other by looking at what criteria the Babylonian astronomers may have used. By considering how closely dates of events and distances of Normal Star passages recur across the periods, combined with how convenient the periods are to use, this has led to a possible understanding of why the particular periods found in the Goal-Year Texts were chosen by their compilers.

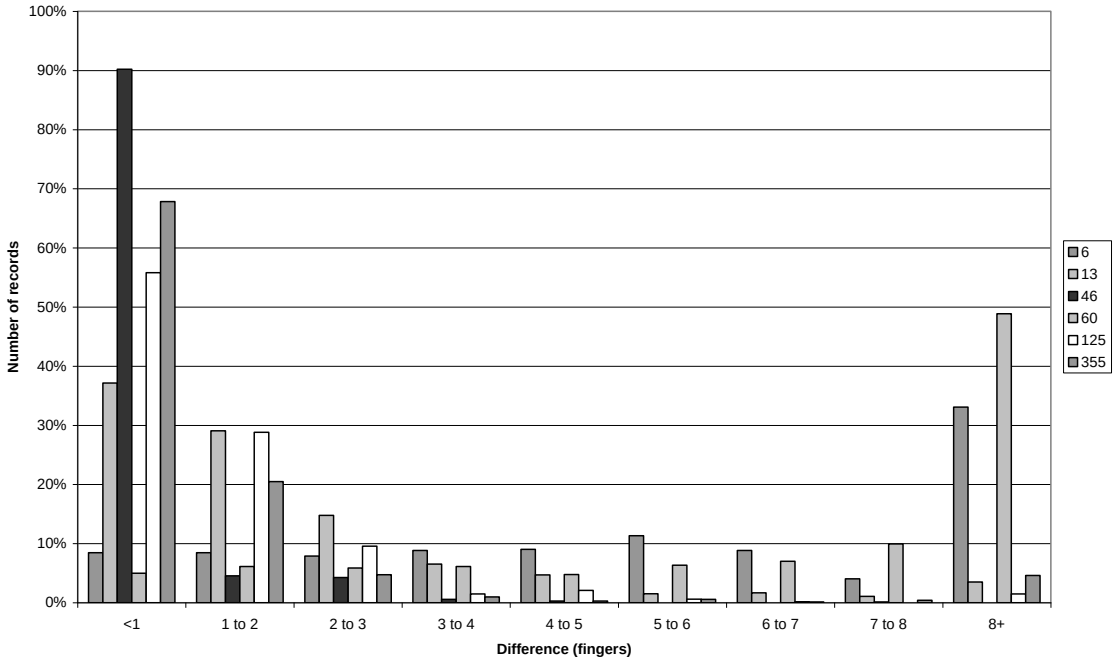

Figure 4.1a: a summary of the latitude changes for Mercury's Normal Star passages, across each of the planetary periods attested the procedure texts. The period used in the Goal-Year Texts is highlighted in black.

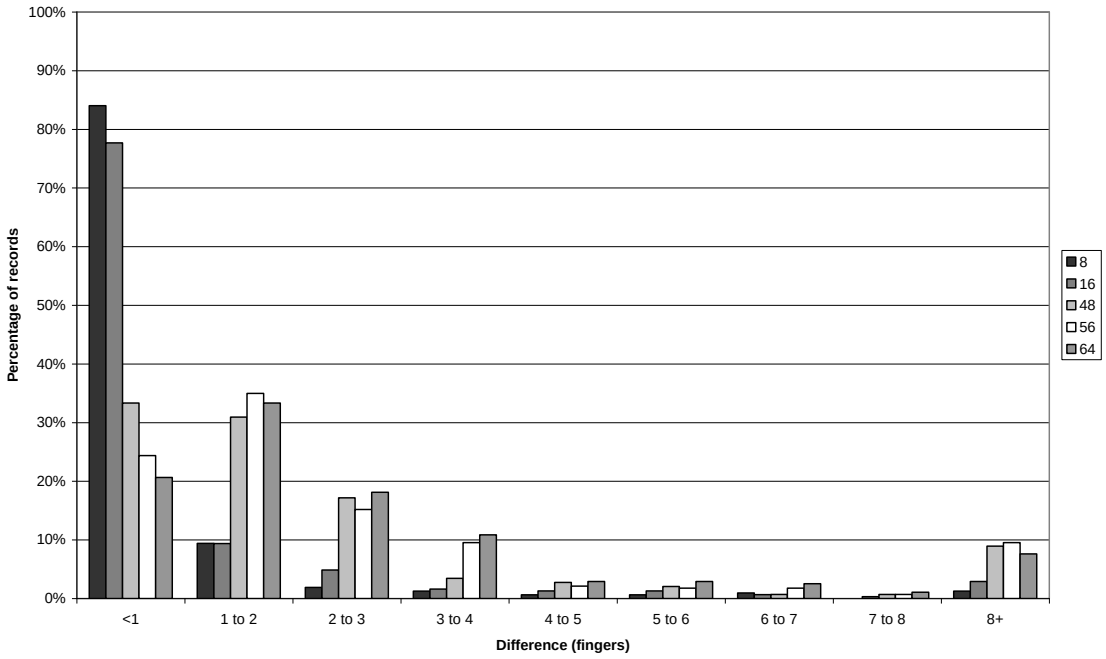

Figure 4.1b: as Figure 4.1a, for Venus' Normal Star passages

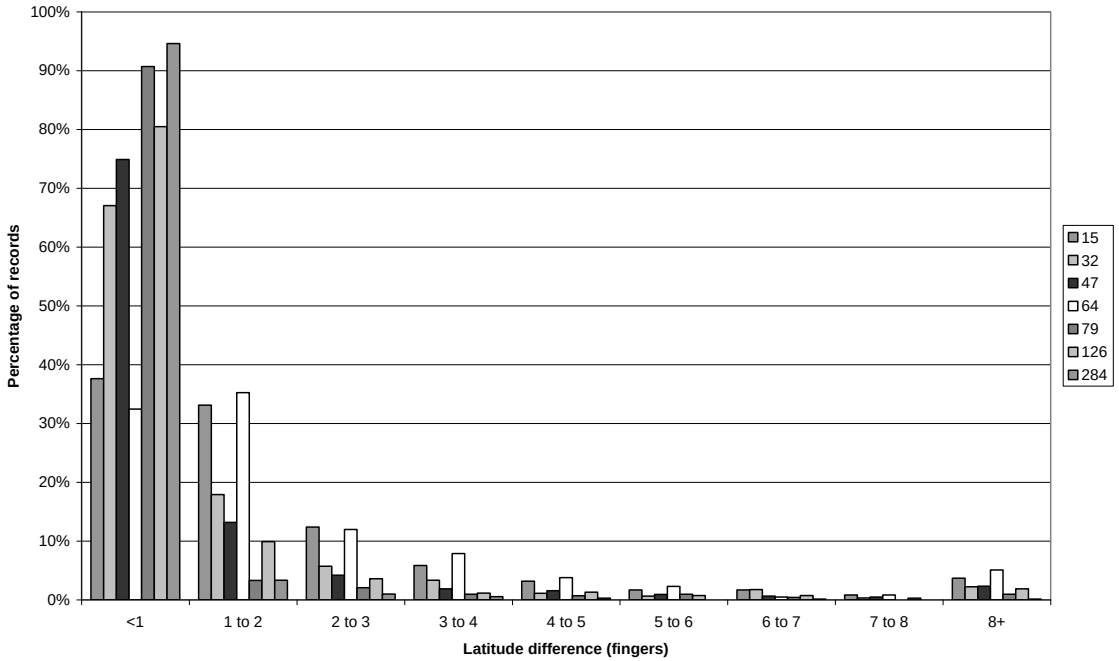

Figure 4.1c: as Figure 4.1a, for Mars' Normal Star passages

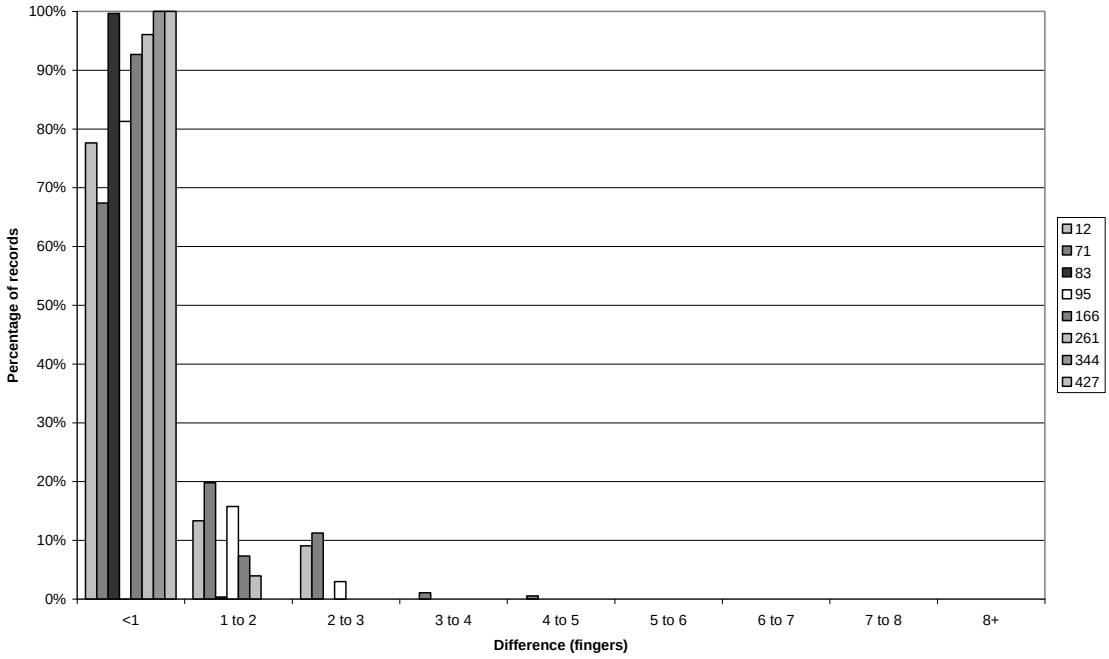

Figure 4.1d: as Figure 4.1a, for Jupiter's Normal Star passages

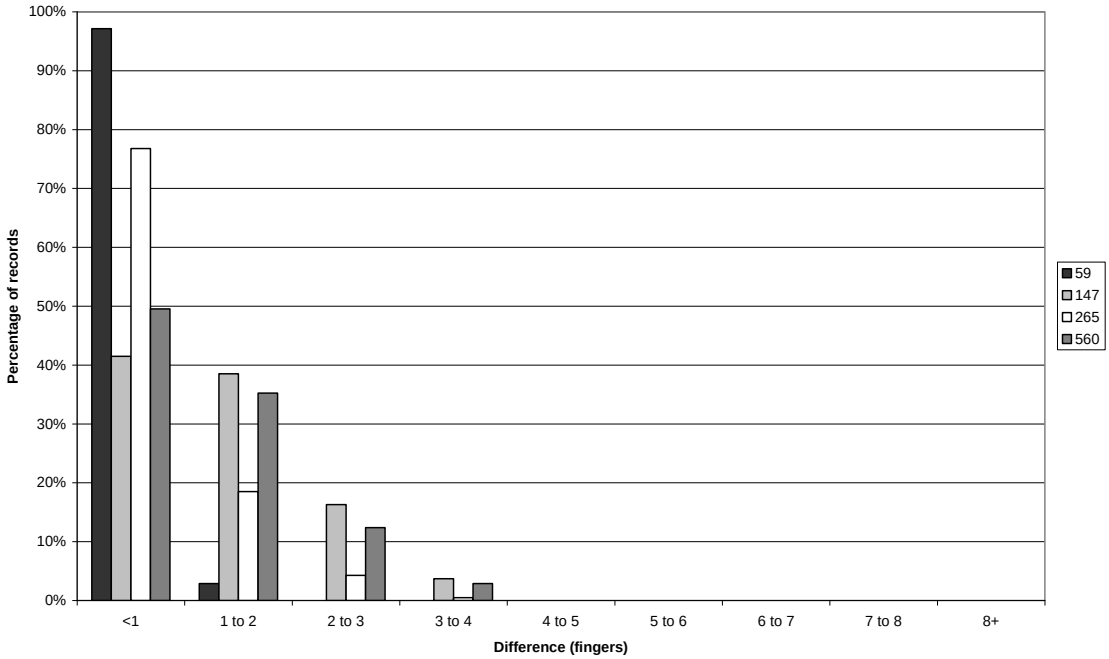

Figure 4.1e: as Figure 4.1a, for Saturn's Normal Star passages

4.7 A comparison of the theoretical date corrections with the procedure texts' records

Having shown which periods and date corrections from the texts are more accurate, or less accurate, one might ask if the procedure texts show an improvement across the period, or a move towards using more accurate periods in the later procedure texts. Unfortunately, the answer is "not really". Even the texts from the start of the Late Babylonian Period (such as DT 78) are already aware of the Goal-Year periods of 71 years for Jupiter, 8 years for Venus, and 59 years for Saturn. While some later texts suggest different periods, they are not an improvement over these Goal-Year periods. Mars' 47-period is also attested in the very early part of the period (in BM 45728).

Some of the early texts mention periods which then do not appear in the later texts, such as 6 years for Mercury and 15 years for Mars. Since these periods are not as accurate as the ones which are used in later texts instead, this could be viewed as an improvement in the planetary theories – that the periods ceased to be used in favour of more accurate ones. It is interesting that the 46-year Goal-Year period for Mercury does not appear in any of the early texts, and this is perhaps explained by the fact that Mercury, being small and fast-moving, is often difficult to observe. Therefore, it might take a while to determine which planetary periods truly predict its recurrence the most accurately.

It is also interesting that the 79-year period for Mars is attested in none of the pre-Seleucid texts except for TU11. This seems strange based on this chapter's earlier demonstrations that it is significantly more accurate than the 47-year period which is attested from the earliest procedure texts. However, it may be linked to the fact that the motion of Mars appeared to be less well-understood in Babylonian planetary theory than any of the other planets, perhaps because of its eccentricity and its long synodic period.[192] On the other hand, Jupiter (whose motion certainly *was* understood well by the Babylonian astronomers[193]) also has a period which is not attested in any of the early texts – the 83-year Goal-Year period.

When attempting to trace the development of non-mathematical planetary theory, another aspect to consider is how well the date corrections suggested in the procedure texts agree with calculations. Table 4.5 shows a comparison of these two types of record: the date corrections in the procedure texts from Table 4.2, and the calculated date corrections from Tables 4.3a-e and 4.4a-e. It shows whether the procedure texts and the theoretical date corrections come close to agreeing with each other.[194]

Note that the procedure texts do not usually specify whether the period applies to Greek-letter phenomena or Normal Star passages, so each period has been compared with each type of event. The notable exception to this is Atypical Text E, from which most of the date corrections come. In this text, each section is headed by a particular sentence, translated by Neugebauer & Sachs as "The passings by of [planet] at the Normal Stars".[195] However, perhaps it was intended to refer to Greek-letter phenomena as well?

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[192] For discussion of this see, for example, Swerdlow (1998) pp 86-87.

[193] As an illustration of this, *ACT* (p. 279) lists 41 ephemerides texts for Jupiter compared with 12 for Saturn, 11 for Mercury, 9 for Venus and 8 for Mars.

[194] In this section I have defined "close to agreeing with each other" as up to 1 day different for Mercury and Venus, up to 2 days different for Mars and Jupiter, and up to 3 days different for Saturn (as discussed earlier in this chapter).

[195] Neugebauer & Sachs (1967) p. 206.

Planet	Record type	Period in Babylonian years	Theoretical date correction –		What date correction is attested in the procedure text?		Do the procedure text date correction and the theoretical date correction agree?
			Mean	Modal			
Mercury	phenomena	6	+16	+16	6yr + 10 days	BM 45728	No
Mercury	passages	6	+9	+10	6yr + 10 days	BM 45728	Yes
Mercury	phenomena	13	-3	-3	13yr - 3 days	Atypical Text E	Yes
Mercury	passages	13	-5	-5	13yr - 3 days	Atypical Text E	No
Mercury	phenomena	46	0	-1	46yr - 1 day	Atypical Text E	Yes
Mercury	passages	46	-1	-1	46yr - 1 day	Atypical Text E	Yes
Mercury	phenomena	125	+2	+3	125yr "same day as before"	Atypical Text E	No
Mercury	passages	125	+3	+4	125yr "same day as before"	Atypical Text E	No
Venus	phenomena	8	-4	-3	8yr - 4 days	Atypical Text E, BM 45728	Yes
Venus	passages	8	-2	-1	8yr - 4 days	Atypical Text E	No
Venus	phenomena	16	-8	-8	16yr - 2 days	Atypical Text E	No
Venus	passages	16	-3	-4	16yr - 2 days	Atypical Text E	Yes
Venus	phenomena	48	+6	+7	48yr + 2 days	Atypical Text E	No
Venus	passages	48	+19	+19	48yr + 2 days	Atypical Text E	No
Venus	phenomena	64	-1	-1	64yr + 1 or 2 days	Atypical Text E	No
Venus	passages	64	+16	+15	64yr + 1 or 2 days	Atypical Text E	No
Mars	phenomena	32	+5	+2	32yr - 5 days	Atypical Text E	No
Mars	passages	32	+18	+19	32yr - 5 days	Atypical Text E	No
Mars	phenomena	47	+2	+4	47yr + 4 days	Atypical Text E	Yes
Mars	phenomena	47	+2	+4	47yr + 12 days	BM 45728	No
Mars	passages	47	+15	+14	47yr + 4 days	Atypical Text E	No
Mars	passages	47	+15	+14	47yr + 12 days	BM 45728	Yes
Mars	phenomena	64	+10	+4	64yr + 4 days	Atypical Text E	Yes

Planet	Record type	Period in Babylonian years	Theoretical date correction –		What date correction is attested in the procedure text?		Do the procedure text date correction and the theoretical date correction agree?
			Mean	Modal			
Mars	passages	64	+6	+9	64yr + 4 days	Atypical Text E	Yes
Mars	phenomena	126	+8	+10	126yr "same day as before"	Atypical Text E	No
Mars	passages	126	-12	-12	126yr "same day as before"	Atypical Text E	No
Jupiter	phenomena	71	0	+1	71yr "same day as before"	Atypical Text E	Yes
Jupiter	passages	71	-9	-3	71yr "same day as before"	Atypical Text E	No
Jupiter	phenomena	83	+17	+17	83yr - 7 days	Atypical Text E, BM 34560	No
Jupiter	passages	83	-9	-7	83yr - 7 days	Atypical Text E, BM 34560	Yes
Saturn	phenomena	30	+9	+9	30yr + 9 days	Atypical Text E	Yes
Saturn	passages	30	doesn't work		30yr + 9 days	Atypical Text E	No
Saturn	phenomena	59	-6	-6	59yr - 5 days	BM 34560	Yes
Saturn	phenomena	59	-6	-6	59yr - 6 days	Atypical Text E	Yes
Saturn	passages	59	-10	-15	59yr - 6 days	Atypical Text E	No
Saturn	phenomena	147	+3	+3	147yr "same day as before"	Atypical Text E	Yes
Saturn	passages	147	-7	+9	147yr "same day as before"	Atypical Text E	No

Table 4.5: a comparison of the theoretical date corrections and the corrections attested in the procedure texts. Each correction has been compared with theoretical date corrections of both Greek-letter phenomena and Normal Star passages. The two dates are said to agree if they are within ±1 day of each other for Mercury and Venus, ±2 days of each other for Mars and Jupiter, and ±3 days of each other for Saturn.

We see from the table that a lot of the date corrections in Atypical Text E which did not work for the Normal Star passage dates, agree very closely for the phenomena dates. Not all of the dates agree, but it seems that too many corrections are in agreement for this to be a coincidence. Perhaps the phrase which heads each planetary section does not refer to a Normal Star passage as it is used in a modern context, but is an unusual piece of terminology.[196]

The table shows that the theoretical date corrections and the procedure texts do *not* agree with each other most of the time. It is likely that many of these disagreements will be due to comparing Normal Star passage dates with corrections which would have been used with Greek-letter phenomena, or vice versa.

Comparing the date corrections from the procedure texts with those from calculations, we find that there are:
21 cases where the theoretical date correction and a procedure date correction disagree,
16 cases where the theoretical date correction and a procedure text date correction agree, of which there are:
5 cases where the mean date correction is a better agreement with the procedure text,
5 cases where the modal date correction is a better agreement with the procedure text,
6 cases where they agree equally well.

From this one concludes that the Babylonian astronomers' methods for determining a date correction do not match particularly with our modern definitions of either the mean or modal value, as expected. As always, there is simply not a large enough set of data to draw any firm conclusions. However, considering the few cases where the mean and mode differ significantly (such as the 64 period for Mars' phenomena, with corrections of +10 vs. +4 days), the procedure text generally agrees more closely with the mode. Based on this, one might tentatively suggest (with the necessary warnings against ascribing modern concepts and terminology to ancient methods, as discussed above) that their methods had more in common what we would now call the mode than the mean.

4.8 A summary of the Goal-Year periods

Table 4.6 summarises the periods used in the Goal-Year Texts, and their theoretical date corrections. The numbers in this table will be referred to again in Chapter 6.

Planet	Record type	Goal-Year period	Date correction – Mean	Modal
Mercury	phenomena	46	0	-1
Mercury	passages	46	-1	-1
Venus	phenomena	8	-4	-3
Venus	passages	8	-2	-1
Mars	phenomena	79	+7	+6
Mars	passages	47	+15	+14
Jupiter	phenomena	71	+0	+1
Jupiter	passages	83	-9	-7
Saturn	phenomena	59	-6	-6
Saturn	passages	59	-10	-15

Table 4.6: a summary of the theoretical date corrections to Goal-Year periods

[196] The text does contain other unusual terminology, as discussed by Neugebauer & Sachs (1967), p.213.

Chapter 5

A comparison of the planetary data in the Goal-Year Texts, Almanacs and Normal Star Almanacs

5.1 Introduction

Now that we have established the theoretical date corrections for the Goal-Year periods, the next step is to investigate what corrections were used, and whether we can deduce how the Babylonian astronomers actually used them in practice. In my opinion this is closely connected to one of the other questions concerning non-mathematical astronomy which has not been conclusively answered: how were the Almanac and Normal Star Almanac planetary predictions made? As discussed in §2.8, a plausible suggestion that they were made empirically from Diary observations, via the Goal-Year Texts. However, it is clear that the data in the predictive texts is not simply an exact copy of the Goal-Year Text data, as will be discussed further below.

Hunger previously examined this problem but concluded that too little material was available for a quantitative study.[197] More data is available now than at the time of Hunger's analysis as more examples of the various texts become identified, dated and accessible for study. Hence, the current investigation is able to draw on records from a larger number of texts and support more firmly some conclusions relating to the questions surrounding this area.

It seems logical to consider Goal-Year Texts as an intermediate step between Diaries and the predictive texts, i.e. the Almanacs or Normal Star Almanacs. Goal-Year Texts are very easy to compile several years in advance of when they are needed, simply by taking the Diaries from the relevant years and extracting the records relating to the planet in question from each one. However, even though they are easy to produce, as a referral tool during the actual goal year they are somewhat inexact and difficult to use due to the data being written in separate sections for each planet rather than by date. Therefore, it follows from this that the next step of recopying the records into a chronological order would make them much more convenient as a tool to refer to during the goal year.

At this point we come to the matter of the date corrections, as deduced in the previous chapter. Following the above sequence of copying the planetary records:

1. Observations in Astronomical Diaries -> 2. Goal-Year Texts -> 3. Predictions in Almanacs and Normal Star Almanacs,

the date correction *could* be applied either at step 2 or step 3 in this sequence. However, recall from §2.7 that parallel records from the Diaries and the Goal-Year Texts were generally extremely similar, often identical. There was no evidence of a systematic date shift between the records in the two texts, and so, if the above sequence is correct, we must look for evidence of a date correction at step 3. In other words, we would expect to find systematic date differences when comparing the dates of parallel events in the Goal-Year Texts and in the predictive texts.

This chapter compares the planetary observations in the Goal-Year Texts with the

[197] Hunger (1999).

planetary predictions in the Almanacs and Normal Star Almanacs, and compares the results with the theoretical date corrections deduced in Chapter 4, to test the theory that the predictions could have been made using the methods described above. Before directly comparing these records, there are several problems with using Goal-Year periods to predict future events that we must account for. These problems will be outlined in the following sections.

5.1.1 Variation of Babylonian year lengths

As described in Chapter 1, the length of the Babylonian year is not constant because there are not a whole number of lunar months in a solar year. The fact that Babylonian years could have either 12 or 13 months implies a complication in using Goal-Year periods for predictions: Goal-Year periods consist of a number of complete Babylonian years and so the exact number of months contained in any particular Goal-Year period can differ depending on how many intercalary months the Goal-Year period includes. Table 5.1 outlines the different numbers of months which the periods found in the Goal-Year Texts can contain.

Year of cycle	1	2	3	4	5	6
Mercury	568/569	569	569	569	569	569
Venus	98/99	99	99	99	99	99
Mars (47 years)	581/582	581	582	581	581	582
Mars (79 years)	977/978	977	977	977/978	977	977
Jupiter (83 years)	1026/1027	1026	1027	1026	1027	1027
Jupiter (71 years)	878/879	878	878	878	878	878
Saturn	729/730	729	729/730	729	730	730

Year of cycle	7	8	9	10	11	12
Mercury	569	569	568/569	569	569	568
Venus	99	99	98/99	99	99	98
Mars (47 years)	581	581	582	581/582	581	581
Mars (79 years)	977	977	978	977	977	977
Jupiter (83 years)	1026	1026/1027	1027	1026	1027	1026
Jupiter (71 years)	878	878	879	878	878	878
Saturn	729	730	730	730	730	729

Year of cycle	13	14	15	16	17	18	19
Mercury	569	569	569	569	569	569	569
Venus	99	99	99	99	99	99	99
Mars (47 years)	581	582	581	581	582	581	581
Mars (79 years)	977	977	977	977	977	977	977
Jupiter (83 years)	1026	1027	1026	1027	1027	1026	1027
Jupiter (71 years)	878	878	878/879	878	879	878	878
Saturn	730	730	729	730	730	729	730

Table 5.1: the number of months in the whole number of Babylonian years used for the Goal-Year periods, for each year in the 19-year Metonic cycle. Year 1 of the cycle contains the Month VI_2. The different number of months in different periods is due to the distribution of intercalary months. Note that in some years the number of months can be one of two values, caused by the Month VI_2 halfway through the year.

For example, we know that an 8-year Goal-Year period was used for Venus' events.

Referring to this table, we see that an 8-year period would contain either 98 or 99 months, depending on which year within the cycle the observations came from. The actual period of Venus' motion, as seen in the previous chapter, is 99 lunar months. This means that for most years the Venus observations can be used to predict events which will happen in exactly the same month of the year 8 years later.

However, for part of some of the years there are only 98 intervening months in the Goal-Year period rather than 99. Following the method of counting forward exactly 8 Babylonian years would lead to predictions of Venus' Greek-letter phenomena for one month later than they will actually occur during the goal year itself. A correction of one month will need to be applied to the data in the years where this is the case.

Clearly, knowing when an extra month would need to be added or subtracted is absolutely crucial for the success of Goal-Year methods of prediction. There is evidence that the Babylonian astronomers were aware of this problem and accounted for it, which is the focus of the following chapter.

5.1.2 Normal Star passages around stationary points

Goal-Year periods generally provide a good approximation for predicting recurring planetary events. However, these patterns of Normal Star passage dates vary greatly as the planet nears a stationary point and its motion becomes less regular. A planet's longitude and latitude around the time of a stationary point during any particular year will not follow exactly the same path as its longitude and latitude around a stationary point one Goal-Year period later. This means that occasionally a passage of a planet by a Normal Star will be observed one year that will then not occur a Goal-Year period later or, equally, that a planet could reach a Normal Star in longitude one year where it had not done so a Goal-Year period previously, due to the longitude at which it became stationary.

An example of this is illustrated in Figure 5.1, which shows the longitude of Venus throughout two Babylonian years one Goal-Year period (8 years) apart. The longitude values have been calculated using JPL's Horizons ephemerides.

The figure displays Venus' longitude throughout the two years and marks the days on which it reaches each of the commonly used Normal Stars. The stars which Venus passed during its period of invisibility are shown in italics. The figure demonstrates that, from about day 100 of the years onwards, the Goal-Year period of 8 years is an excellent fit for Venus' motion. Note that Venus consistently reaches each Normal Star in longitude one or two days earlier in SE 112 than in SE 120, as we would expect from the date corrections in Chapter 4. However, before day 100 there is much less agreement between the two years concerning the dates when Venus passes by the stars, due to the irregular motion around the stationary points. Highlighted in the figure are two stars which Venus would have reached in longitude during one year but not during the other – γ Geminorum in SE 112 and β Tauri in SE 120.

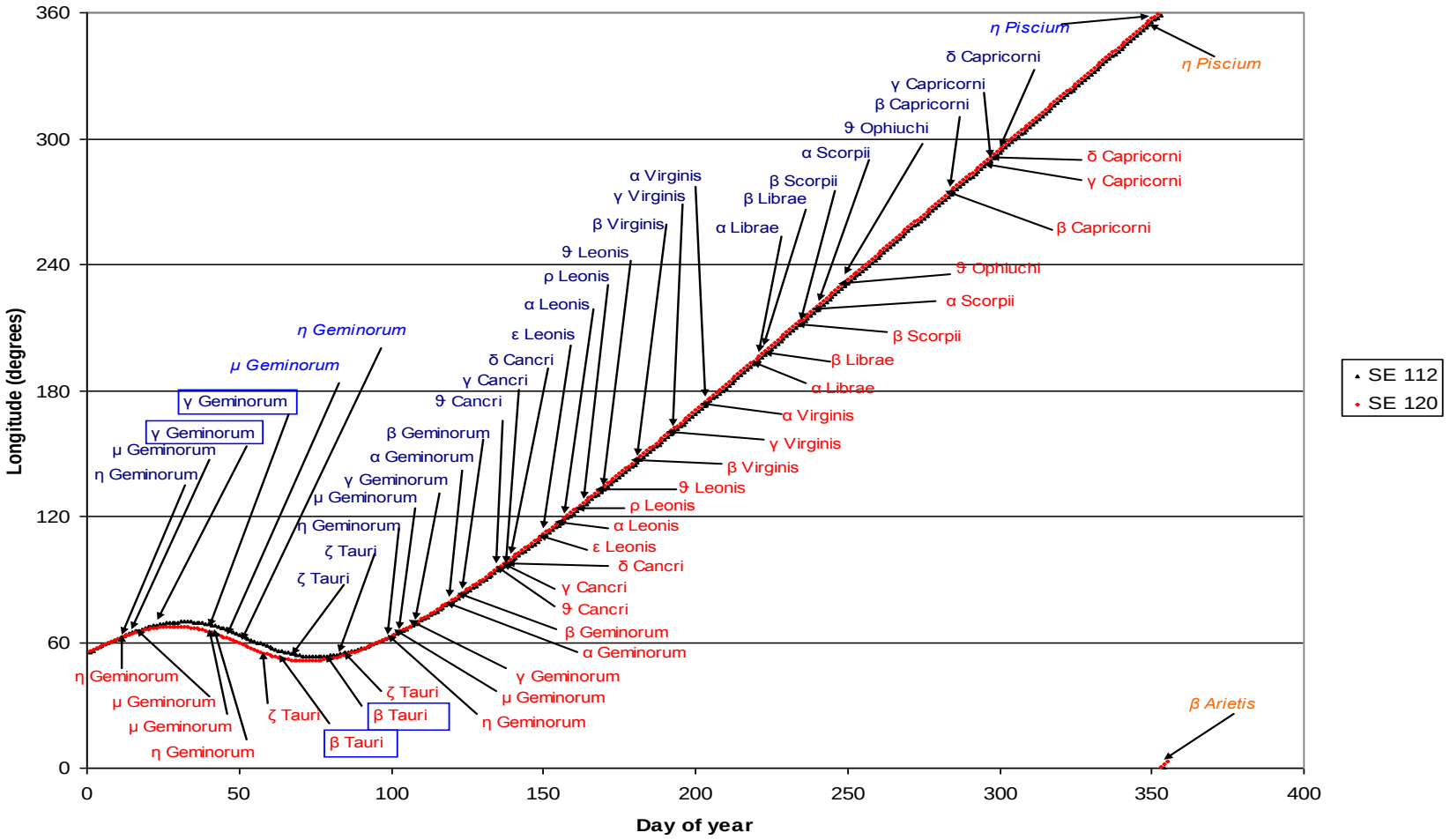

Figure 5.1: Venus' longitude during the Babylonian years SE 112 and SE 120, marking the points where the planet passed by each Normal Star. Star names in italics were passed during Venus' periods of invisibility. The boxes around γ Geminorum and β Tauri highlight stars which the planet moved past in one year but not the other, showing that these planetary passages presumably could not have been predicted using Goal-Year methods.

This shows that predicting events using Goal-Year methods could lead to occasional planet-Normal Star passages being predicted that would not actually happen during a particular year, or passages failing to be predicted because they did not occur one Goal-Year period previously. It is likely that this would have been an extremely rare event, because it requires a quite specific set of circumstances – the planet's motion would need to reach its stationary point at about the same longitude as a Normal Star; and the equivalent stationary point a Goal-Year period earlier or later would have to occur at a longitude different enough that it clearly did *not* pass the same Normal Star. Nevertheless, the question remains unanswered whether the Babylonian astronomers were aware of this and accounted for it.

5.1.3 Accuracy of the Goal-Year periods in terms of date and latitude

As shown in the previous chapter, planetary events will tend to reoccur a particular number of days earlier or later in the year after a Goal-Year period has passed. It is hoped that a comparison of the dates of records of the same event in the Goal-Year texts and the predictive texts will show date differences consistent with the theoretical date corrections which were summarised in Table 4.6.

The previous chapter also showed that the latitude changes across the Goal-Year periods were almost always negligible, or, in other words, that the distance between a planet and star at the time of a planetary passage would generally be the same for the equivalent planetary passage a Goal-Year period later. Therefore, we would expect to find that Goal-Year records and predictive records of the same planetary passages refer to the same planet-star distance. Figure 5.2 summarises these latitude differences by showing the Goal-Year Texts' planetary periods from Figures 4.1a-e.

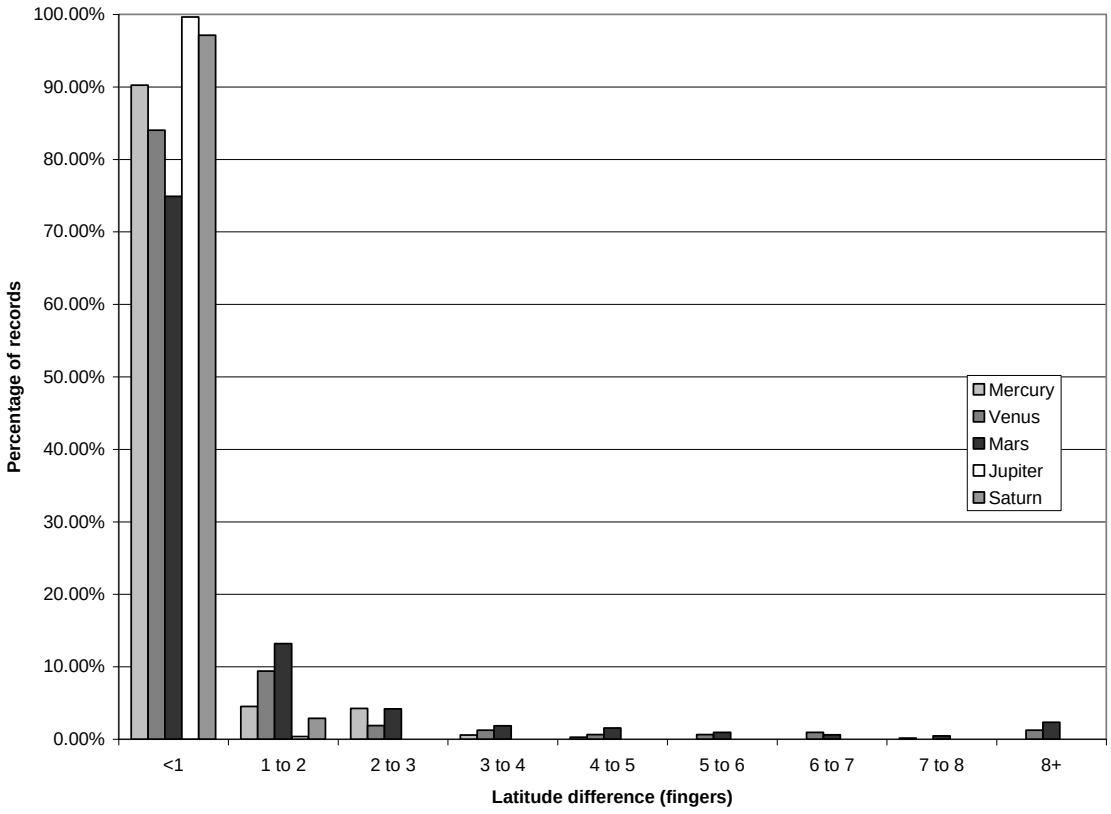

Figure 5.2: a summary of the theoretical latitude differences between two corresponding planetary passages one Goal-Year period apart.

5.2 A comparison of the planetary records in Almanacs, Normal Star Almanacs, and Goal-Year Texts

5.2.1 The database

For this investigation, all the Goal-Year Texts, Almanacs and Normal Star Almanacs were examined to find cases where the same planetary event is mentioned in at least two of these text types. Goal-Year Text records were compared with predictive texts for the same year as the goal year, i.e. in this context the Goal-Year Text records were treated as data to be used for making predictions in the goal year, rather than records from the observational years.

The full database can be found in Appendices F and G. Appendix F shows all examples of matching planetary predictions found both in Normal Star Almanacs and in Almanacs, in order to show whether we need to consider the data from these two sources separately.

As always, small data sets make it more problematic to draw firm conclusions. While, as Tables 2.7 and 2.8 demonstrated, there are extant Almanacs for 51 different years and Normal Star Almanacs for 63 different years, only 14 of these years overlap and in only 5 years are there actually corresponding examples of the same planetary record. Thus, the total remaining comparison of Normal Star Almanac and Almanac data is 27 pairs of planetary events. They show that there are no significant differences between records found in the two texts: in 22 of these cases the records are identical, as far as the text is preserved.

Of the five cases where the records differ, three are most likely examples of copying errors on the part of either the original scribe or a modern copyist. The reasoning behind this is explained below for each case:

> 8 AN *ina* RÍN IGI
> "The 8th, Mars' first appearance in Libra."
> (LBAT **1059, Rev. 1 (Normal Star Almanac for SE 201))

> 8 AN ⌜*ina* A IGI⌝
> "The 8th, Mars' ⌜first appearance in Leo⌝."
> (LBAT 1151, Obv. 14 (Almanac for SE 201))

The cuneiform signs for Leo and Libra are quite similar. Calculating the longitude of Mars on this date shows that it was at a longitude of around 182º, i.e. in the zodiacal sign of Libra.

> 2 GENNA *ina* SAG RÍN UŠ
> "The 2nd, Saturn stationary in the beginning of Libra."
> (LBAT **1059, Rev. 25 (Normal Star Almanac for SE 201))

> 20 GENNA *ina* SAG RÍN ⌜x⌝.
> "The 20th, Saturn ⌜x⌝ in the beginning of Libra."
> (LBAT 1151, Rev. 8 (Almanac for SE 201))

It is very likely that in the record from the Almanac the date should have been the 2nd. The record is at the beginning of a month and is followed by several records earlier than day 20 of the month, suggesting that the 20th is the wrong date.

29 GU_4-UD *ina* ŠÚ *ina* HUN IGI
"The 29th, Mercury's first appearance in the west in Aries."
(LBAT **1059, Rev. 35 (Normal Star Almanac for SE 201))

29 GU_4-UD *ina* ⌜ŠÚ *ina* HUN ŠÚ⌝
"The 29th, Mercury's ⌜last (sic) appearance in the west in Aries⌝"
(LBAT 1151, Rev. 12 (Almanac for SE 201)

It is clear from reading the other Mercury records in the Almanac that it contains a scribal error and "first appearance" in this case.

The remaining two records that differ are, in one case, a slightly different use of terminology, and in the one remaining case a disagreement on the date of a planetary event.

21 *dele-bat ina* NIM *ina* SAG HUN IGI
"The 21st, Venus' first appearance in the east in the beginning of Aries."
(LBAT 1005, Rev. 3' (Normal Star Almanac for SE 92)

21 *dele-bat ina* NIM *ina* HUN IGI
"The 21st, Venus' first appearance in the east in Aries."
(LBAT *1118-9, Rev. 11 (Almanac for SE 92))

5 *dele-bat ina* NIM *ina* PA IGI
"The 5th, Venus' first appearance in the east in Sagittarius."
(LBAT **1059, Rev. 13 (Normal Star Almanac for SE 201))

6 *dele-bat ina* NIM [*ina* x IGI …]
"The 6th, Venus' [first appearance] in the east [in x …]"
(LBAT 1151, Rev. 3 (Almanac for SE 201))

Given that writing an Almanac or Normal Star Almanac involves copying and recopying records several times, an occasional copying error is inevitable (especially once we allow for errors in modern copying and translations as well). Discrepancies in date may also result from events being recorded differently in parallel Diaries, as was discussed in Chapter 2.

5 differences out of 28 may seem to be more than an 'occasional' copying error, but four of these errors are from the same Almanac and this could therefore be viewed as an isolated example of a particularly badly copied tablet. Otherwise, the number of discrepancies in the dataset is not significant.

Only one out of the 28 examples shows any disagreement in the predicted *date* of an event (which is what this investigation is interested in), and one can therefore reasonably conclude that any date corrections that were applied to predictions in the Normal Star Almanacs were applied equally to the Almanacs. Consequently, the subsequent sections of this investigation does not examine the Normal Star Almanac data differently from the Almanac data, but treat the records which they have in common (i.e. dates of Greek-letter phenomena) as one dataset.

Appendix G contains all extant examples of an equivalent record existing in both a Goal-

Year Text and an Almanac or Normal Star Almanac.[198] The records did not need to be complete and unbroken to be included in the database, as long as each record of the pair contained either an unbroken date or measurement of a planet-Normal Star distance for comparison.

In the appendices, the translations have been slightly abbreviated for reasons of space. For example, remarks from the Goal-Year Texts on a planet's size or brightness at its first appearance, or time measurements around a planet's first or last appearance, have not been included. However, dates of "ideal" first appearances and "last seen" dates around the times of last appearances have been included; there is further discussion of this later. Below are some examples of typical record pairs from the database.

> [IZI …] ⌜GE$_6$ 10⌝ *ina* ZALÁG *dele-bat e* LUGAL 3 SI
> "[Month V…] ⌜Night of the 10th,⌝ last part of the night, Venus was 3 fingers above α Leonis."
> (*ADART* Vol. VI no. 15, Obv. 13 (Goal-Year Text for SE 106))

> [IZI …] GE$_6$ 8 *ina* ZALÁG *dele-bat e* LUGAL 3 SI
> "[Month V…] Night of the 8th, last part of the night, Venus was 3 fingers above α Leonis."
> (LBAT *1013, Obv. 8' (Normal Star Almanac for SE 106))

We can compare both the date and measurement in this pair of records.

> APIN GE$_6$ 16$^{?}$ USAN AN SIG SI MÁŠ 2 KÙŠ
> "Month VIII, night of the 16$^{th?}$, first part of the night, Mars was 2 cubits below β Capricorni."
> (*ADART* Vol. VI no. 69, Rev. 2 (Goal-Year Text for SE 194))

> GAN … ⌜GE$_6$⌝ 2 USAN AN SIG SI MÁŠ […]
> "Month IX … ⌜Night of the⌝ 2nd first part of the night, Mars was below β Capricorni […]"
> (LBAT 1057, Rev. 2' (Normal Star Almanac for SE 194))

Here the date is available for comparison, though the distance measurement has been lost.

> ⌜AB 20 MÚL$^{?}$-BABBAR$^{?}$⌝ [*ana* ME E-*a* …]
> "'⌜Month X, the 20th, Jupiter's$^{?}$⌝ [acronychal rising …]"
> (*ADART* Vol. VI no. 17, Obv. 1' (Goal-Year Text for SE 107))

> [AB…] 20 MÚL-BABBAR ⌜*ana* ME E-*a*⌝
> "[Month X…] The 20th, Jupiter's ⌜acronychal rising.⌝'"
> (LBAT 1016, Rev. 3' (Normal Star Almanac for SE 107))

Again, the dates can be compared.

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[198] Recall that "equivalent" here refers to comparing Goal-Year Text records with predictive texts which cover the same Babylonian year as the goal year.

IZI 24 GU_4-UD *ina* NIM *ina* A IGI KUR NIM-*a* 16,40 *na-su in* 21 IGI
"Month V, the 24th, Mercury's first appearance in the east in Leo; it was bright (and) high, rising of Mercury to sunrise: 16°40'; (ideal) first appearance on the 21st."
(*ADART* Vol. VI no. 86, Obv. 22 (Goal-Year Text for SE 236))

ˈIZIˈ … 21 GU_4-UD *ina* NIM *ina* A IGI
"ˈMonth Vˈ … The 21st, Mercury in the east in Leo first visibility."
(LBAT 1174, Obv. 10 (Almanac for SE 236))

In this case, we can compare the predicted date from the Almanac with either the observed or the ideal date from the Goal-Year Text. 26 of the Greek-letter phenomena records taken from the Goal-Year Texts include either a second (ideal) date for first visibilities as above, or the phrase "from the x^{th} when I watched I did not see it" in the case of last visibilities.

Note that in some cases found in the Appendix the two records are clearly predicting the same events, but the date differs by a month. This is to be expected, as was previously outlined in §5.1. These "month shifts" have been ignored in this chapter, where we are only interested in the date differences of events; how the month shifts and other calendrical issues might have been dealt with is the focus of Chapter 6.

For reference, the database contains the following number of matching pairs of records:

84 examples of overlapping Normal Star passage predictions from the Goal-Year Texts and Normal Star Almanacs;
Mercury 13 Venus 37 Mars 27 Jupiter 4 Saturn 3 records.

39 examples of overlapping Greek-letter phenomenon predictions from the Goal-Year Texts and Normal Star Almanacs;
Mercury 20 Venus 3 Mars 2 Jupiter 5 Saturn 9 records.

42 examples of overlapping Greek-letter phenomenon predictions from the Goal-Year Texts and Almanacs;
Mercury 24 Venus 3 Mars 5 Jupiter 3 Saturn 7 records.

In total, allowing for partially broken records, this leaves us with the following numbers of record pairs to analyse:

64 records which can be used for comparing recorded planet – Normal Star distances.
53 records which can be used for comparing recorded dates of planet – Normal Star passages.
81 records which can be used for comparing dates of Greek-letter phenomena.

Of the Greek-letter phenomenon records in the database, only a few included an ideal or "last seen" date:

Number of records with both an observed and ideal or "last seen" date: 18 (14 for Mercury, 2 for Venus, 2 for Saturn)
Number of records with an ideal or "last seen" date only: 7 (4 for Mercury, 1 for Jupiter, 2 for Saturn)

5.2.2 Predicted distances of Normal Star passages across the Goal-Year periods

As demonstrated in Chapter 4, the theoretical analysis implies that Normal Star passages in the Normal Star Almanacs and the Goal-Year Texts should record very similar distances for the same events. Table 5.2 summarises the results of this comparison between the texts and shows that, broadly, the results from the Babylonian texts agree with the theoretical results. In most (75%) of the remaining pairs of records, the distance measurements exactly match each other, adding strong support to the theory that Normal Star Almanac predictions are from the same source as the Goal-Year Text records.

Planet	Number of cases where the distance measurement:		
	Matches	"Nearly" matches	Does not match
Mercury	**6**	**2**	**1**
Venus	**23**	**5**	**4**
Mars	**15**	**1**	**2**
Jupiter	**2**	**1**	**0**
Saturn	**2**	**0**	**0**
All	**48**	**9**	**7**

Table 5.2: A comparison of the preserved distance measurements in records of Normal Star passages found in both the Goal-Year Texts and the Normal Star Almanacs, showing when the distance recorded in the two texts agreed or disagreed.

Of the record pairs where the recorded distances are not an exact match, 14% are classed as "nearly" matching and only 11% are classed as being notably different from each other. I shall now examine the non-matching records in more detail.

The nine cases of measurement pairs which have been classed as "near" matches are shown in Table 5.3. "Nearly" matching records include measurements that differed from each other by ½ a cubit or less, or up to a cubit apart where one of the readings is marked as uncertain. The seven cases of measurement pairs which are classed as being clearly "different" from each other are shown in Table 5.4; "different" measurements include those where the two texts differ from each other by a cubit or more.

	Year	Normal Star Almanac record	Goal-Year Text record
Mercury	SE 96	1 2/3 cubits	1 5/6 cubits
	SE 194	1 ⌜cubit x⌝ fingers	1 cubit 4 fingers
Venus	SE 107	4 cubits	5? cubits
	SE 107	1 cubit 8 fingers	1 cubit 10 fingers
	SE 192	2/3 cubit	1/3? cubit
	SE 194	⌜4?⌝ […]	5 cubits
	SE 194	3 cubits	2? cubits
Mars	SE 96	3 cubits	2 1/2 cubits
Jupiter	SE 184	2 1/2 cu[bits]	2 cubits

Table 5.3: Details of the Normal Star passage distances from Table 5.2 where the measurement

"nearly" agreed.

Planet	Year	Normal Star Almanac record	Goal-Year Text record	Notes
Mercury	SE 201	4 cubits	1 cubit	GYT SE 155: 4 cubits
Venus	SE 96	3 cubits	2 cubits	
	SE 96	1 1/3 cubits	2 1/2 cubits	
	SE 107	2 cubits	1/2 cubit	
	SE 194	3 cubits	5 cubits	GYT SE 186: 3 cubits
Mars	SE 107	3 1/2 cubits	2 [cubits]	
	SE 194	2 cubits	1 cubit	

Table 5.4: Details of the Normal Star passage distances from Table 5.2 where the measurement disagreed. Where possible, the distance measurement from a previous text has also been given for comparison.

A possible explanation for records which "nearly" match is that the measurements may have been copied from different Astronomical Diaries for the same year. As discussed in Chapter 2, a few examples remain of two Diaries which cover the same month and which have recorded a measurement or a date slightly differently. Recall that Tables 2.3, 2.4 and 2.5 gave details of these matching records and showed that (for records of the same event on the same date) a difference of opinion regarding a distance measurement, up to a difference of around half a cubit, is quite common. I therefore took a half a cubit to be the division between measurements which "nearly" matched and those which were "different", which allowed for a clear division between the two categories. I suggest that a straightforward way to account for a pair of records which "nearly" match is the situation where the Goal-Year Text had been copied from one Diary, and the Normal Star Almanac had been created using records copied from an alternate Diary.

Another explanation for records in either the "nearly" agreeing or the "different" categories is, as discussed above, that they may be due to copying errors. It can be tempting to ascribe all Babylonian records which do not fit our expectations to "scribal error", but this is generally unhelpful at best. Nevertheless, there are many cases where the wrong sign or number has been included in a text and clearly another one was intended. For example, Table 5.4 also shows the two cases where the comparison seemed to be "different" or not agree in the two texts for the same year, but when the Goal-Year Text from one Goal-Year period further back *did* agree with the Normal Star Almanac.

At first one might assume that a differing pair of records was an indication of an inaccurate prediction, or an argument against our theory that the two texts' records are derived from the same source. However, in these two comparisons this is demonstrably *not* the case, as the Normal Star Almanac prediction ultimately agrees with observation. Instead, this is almost certainly a straightforward example of a copying error in the Goal-Year Text. However, one must be wary of extrapolating this explanation to *all* of the "different" measurement pairs.

5.2.3 Predicted date corrections of Normal Star passages across the Goal-

Year periods

Table 5.5 summarises the date differences for the data relating to NS passages. For each pair of equivalent records the table shows the calculated differences between the given dates, and the number of records which show each correction. For example, a correction of "-2" means that the date of the Normal Star Almanac record is 2 days earlier in the month than the Goal-Year Text's record of the same event.

Mercury	Correction applied, in days	-1	0	1	
	Number of records	8	2	1	
Venus	Correction applied, in days	-3	-2	-1	1
	Number of records	2	11	10	1
Mars	Correction applied, in days	15	16	17	
	Number of records	2	12	2	
Jupiter	Correction applied, in days	-7			
	Number of records	1			
Saturn	Correction applied, in days	-22			
	Number of records	1			

Table 5.5: The differences between dates of events, when comparing equivalent Normal Star passage records in the Goal-Year Texts and Normal Star Almanacs.

As is so often the case in these investigations, a problem with analysing these records is the extremely small amount of remaining data. For Mercury, Venus and Mars we can infer date corrections from the comparisons, analogous to those produced from the theoretical data in the previous chapter. However, there is only one remaining pair of records for Jupiter or Saturn and so we cannot draw any conclusions for the date corrections applied to these planets.

Table 5.6 summarises the modal date corrections that the records indicate that the Babylonian astronomers used for planetary passages. The modal corrections suggested by the theoretical data from Chapter 4 are also shown, along with the percentage of the records which fall within ± one day of the peak value in each case.

	Date corrections using calculations from Chapter 4		Date corrections using Normal Star passage records from Babylonian texts		
	Modal date difference in days	Percentage within ± 1 day of peak value	Modal date difference in days	Total no of records	Percentage within ± 1 day of peak value
Mercury	-1	99%	-1	11	91%
Venus	-1	92%	-2	24	96%
Mars	+14	78%	+16	16	100%
Jupiter	-7	55%	-7	1	100%
Saturn	-15	32%	-22	1	100%

Table 5.6: A summary of planetary passage date corrections: a comparison of expected date corrections from Chapter 4's theoretical analysis and date corrections from Babylonian records of Normal Star passages.

The table demonstrates that, for Mercury and Venus, the Babylonian records imply the use of date corrections very close to those expected from the theoretical data. The theoretical

data showed that using a date correction of -1 day for Mercury or Venus would predict the correct date of a planetary passage over 90% of the time, and the Babylonian records bear out this theory. While Venus' modal correction from the Babylonian records is -2 days rather than -1 day, the difference is very small: eleven records in Table 5.5 show a difference of -2 days compared with ten showing a difference of -1 day.

For Mars, the date difference between records in the two texts is very consistently 16 days. This does not completely agree with the theoretical data, which suggested a modal correction of 14 days, suggesting that if the Babylonian astronomers were using a correction of 16 days they would often have been expecting to view the planetary passage a day or two after the passage theoretically took place. Calculations show that over the course of one day Mars' longitude changes by an average of 0.51º, with a standard deviation of 0.32º, meaning that most of the time Mars would have moved 1º or so of longitude between the theoretical passage date and the expected Babylonian passage date. Given the uncertainty in determining at exactly what point a planet is said to have passed by a Normal Star (see Chapter 3), a longitude difference of 1º or less suggests that the date correction used in the Normal Star Almanacs would still be a good approximation for predicting Mars' Normal Star passages.

Again, no firm conclusions can be drawn from the extremely small amount of data remaining for Jupiter and Saturn.

The corrected periods used for predicting planetary passages should also be applicable to dates when a planet changes zodiacal sign. However, these dates are recorded in very few Goal-Year Texts (*ADART* Vol. VI Nos. 77, 86, 90 and 91 only), suggesting that they were not explicitly predicted in the same way as dates of Greek-letter phenomena were, but perhaps deduced using dates of passing nearby Normal Stars.[199]

Observations and predictions of sign entry dates can be found in the Diaries and the Almanacs respectively. Comparing dates when a planet is observed moving into a particular zodiacal sign in one year, with predicted dates of the planet moving into the same sign exactly one Goal Year period later, should show the same date corrections as Table 5.6. Very few such comparisons are available from the remaining data; no statistical analysis can be made of these record pairs but for completeness they have been included in Table 5.7.

Text		Date (year SE)			Date difference	Planet	Zodiacal sign reached
Diary -178 C	'Rev. 16'	133	XII	4			
LBAT 1135	Rev. 4	179	XII	8	+4	Mercury	Pisces
Diary -118 B	UE 1	193	VII	3			
LBAT 1151	Obv. 14	201	VII	1	-2	Venus	Sagittarius
Diary -83	'Obv.' 20'	228	III	23			
LBAT 1174	Obv. 6	236	III	21	-2	Venus	Leo
Diary -122 B	'Obv.' 10'	189	II	7			
LBAT 1174	Obv. 1	236	I	26	-11	Mars	Aries
Diary -122 D	'Rev.' 8'	189	VI_2	8			
LBAT 1174	Obv. 12	236	VI	29	-9	Mars	Cancer

[199] See the discussion of these issues in §3.3; also Huber (1958), Jones (2004), Steele & Gray (2007).

Diary -136 A	'Obv. 6'	175	VI	30				
LBAT 1164-5	Obv. 12	234	V	30		-30	Saturn	Scorpio

Table 5.7: A comparison of the dates of observations of a planet changing zodiacal signs from the Astronomical Diaries, with predictions of the same event from an Almanac for one Goal-Year period later.

5.2.4 Predicted date corrections of Greek-letter phenomena across the Goal-Year periods

Table 5.8 summarises the date differences for the data relating to Greek-letter phenomena. As was the case with Table 5.5, the table shows the calculated differences between the recorded dates of each pair of equivalent records in the Goal-Year Texts and Almanacs or Normal Star Almanacs, and the number of records which show each correction.

Table 5.9 shows data from the same planetary records as Table 5.8, and also includes comparisons of ideal dates of first visibilities or "last seen" dates of last visibilities when these have been recorded. For the present analysis, this means that planetary visibility phenomena for which only an ideal or "last seen" date remained in the Goal-Year Text will only appear in Table 5.9, and phenomena for which only an observed date remained will appear in both Tables 5.8 and 5.9. For phenomena where the Goal-Year text had *both* an observed and an ideal or "last seen" date, the difference involving the observed date is shown in Table 5.8, and the difference involving the ideal or "last seen" date in Table 5.9.

Mercury	Correction applied, in days	-7	-5	-4	-3	-2	-1	0	1	4	7	10
	Number of records	1	3	1	3	7	4	11	2	1	1	2
Venus	Correction applied, in days	-7	-6	-5	-4							
	Number of records	1	1	1	3							
Mars	Correction applied, in days	-6	0	4	8	9	17					
	Number of records	1	2	1	1	1	1					
Jupiter	Correction applied, in days	-2	-1	0	1							
	Number of records	1	2	3	1							
Saturn	Correction applied, in days	-13	-12	-7	-6	-5	18	22	24	28		
	Number of records	1	1	3	1	2	1	1	2	1		

Table 5.8: The differences between dates of events, when comparing equivalent records of Greek-letter phenomena in the Goal-Year Texts and Normal Star Almanacs or Almanacs.

Mercury	Correction applied, in days	-7	-4	-3	-2	-1	0	1	3	4	7	10
	Number of records	1	1	3	3	4	22	3	1	1	1	2
Venus	Correction applied, in days	-5	-4									
	Number of records	1	5									
Mars	Correction applied, in days	-6	0	4	8	9	17					
	Number of records	1	2	1	1	1	1					
Jupiter	Correction applied, in days	-2	-1	0	1							
	Number of records	1	2	3	2							

Saturn	Correction applied, in days	-17	-10	-9	-7	-6	-5	18	22	24	28
	Number of records	2	1	1	3	1	2	1	1	2	1

Table 5.9: The differences between dates of events, when comparing equivalent records of Greek-letter phenomena in the Goal-Year Texts and Normal Star Almanacs or Almanacs, as Table 5.8 but including "ideal" dates and "last seen" dates when available.

As we saw for the planetary passage data, the small amounts of available data mean that it is not easy to draw firm conclusions from the results. This is particularly apparent for Mars and Saturn, where the spread of date corrections shows no clear peak. For Mercury, there is both a clear peak correction and a very wide spread of data, due to the fact that there are a lot more extant Mercury records than for any of the other planets. Venus and Jupiter demonstrate a much more consistent correction but only from a small number of available record comparisons.

Contrasting Tables 5.8 and 5.9 also gives us an idea of how the ideal dates found in the Goal-Year Texts could have been used in practice. Again, there is only really enough data for this to become apparent in the case of Mercury. In both tables, Mercury's modal correction to dates of Greek-letter phenomena is at ±0 days, but the number of records showing this correction is significantly higher when we take into account the ideal dates of events. This leads to the conclusion that ideal dates must have been an important part of compiling the predictive texts.

Table 5.10 summarises the most common date corrections which the records indicate that the Babylonian astronomers were using for Greek-letter phenomena. In the same way as Table 5.6, the modal corrections from Chapter 4's theoretical calculations are again shown, along with the percentage of the records which fall within ± one day of the modal value.

Examining the percentages of results which fall close to the modal value provides an interesting contrast between Table 5.10 and Table 5.6. Table 5.6 showed that, for any particular planet's Normal Star passages, the date corrections applied were nearly always the same, to a high degree of consistency. However, here we see that there is a much wider spread of the data for Greek-letter phenomena. This means that, even though the modal corrections for Babylonian dates of Greek-letter phenomena generally match the expected theoretical values, the data show a much lower consistency in the date corrections. This is despite the fact that in Chapter 4 it was shown that the theoretical date corrections were much more consistent (in terms of percentage of records falling close to the modal date correction) for dates of Greek-letter phenomena than Normal Star passages.

	Date corrections using calculations from Chapter 4		Date corrections using Greek-letter phenomena records from Babylonian texts		
	Modal date difference, in days	Percentage within ± 1 day of peak value	Modal date difference, in days	Total no of records	Percentage within ± 1 day of peak value
Mercury	-1	99%	0	36	47%
				42	(69% using ideal dates)
Venus	-3	99%	-4	6	67%
				6	(100% using ideal dates)
Mars	+6	82%	0	7	29%
Jupiter	+1	95%	0	7	86%
				8	(88% using ideal dates)

Saturn	-6	98%	-7	13 15	31% (27% using ideal dates)

Table 5.10: A summary of Greek-letter phenomena date corrections when comparing expected date corrections from Chapter 4's theoretical analysis with date corrections from Babylonian records of Greek-letter phenomena.

From Table 5.10, we see that the Babylonian astronomers did not generally apply a date correction to Mercury's Greek-letter phenomena, despite the theoretical data suggesting that a date correction of -1 day would be most commonly seen. This might imply that quite often the Babylonian astronomers would be expecting to observe Mercury for the first time the day *after* its true first visibility, and watching out for it a day too late. However, given that Mercury is notoriously difficult to spot at the time of its appearance or disappearance (due to, for example, the challenges of spotting a small object on a bright horizon close to the Sun), I do not believe that this makes the Babylonian corrections "wrong" in any way. Instead I suspect it highlights the difference between the limits of observation under ideal observing conditions and what may be possible in real-life observing conditions. Further issues concerning Mercury's visibility patterns are analysed in Chapter 7.

5.3 Conclusions

In conclusion, there is generally a high level of agreement between the planetary records found in a Goal-Year Text, and the Almanacs or Normal Star Almanacs predicting events for the goal year. This suggests that the records found in the Goal-Year Texts could have been used in the creation of the Almanacs and Normal Star Almanacs. Statistical analysis of the records shows that, if this were the case, the Babylonian astronomers consistently applied small corrections of a few days to the dates of events from Goal-Year records, and that records of planet-Normal Star distances at the time of a planetary passage remain unchanged between the various texts. These date corrections generally agree very well with the theoretical date corrections which were calculated in the previous chapter.

Analysis of the Greek-letter phenomena dates also showed that, where both an observed date and an ideal date of an event were available, the predictions were much more likely to have been made using the ideal date. This is consistent with the view, discussed in Chapter 2, of an ideal date being an estimated correction to the date of an event, to take into account bad weather or other problems with observing. In other words, the "date correction" between an ideal and observed date could be viewed as a *modification* of the date correction applied across a planetary period (which is largely constant for each planet); a modification that varies from event to event depending on observing conditions. It therefore makes sense to use the ideal date, where one is necessary and available, as a starting point for predicting the dates of future events.

Chapter 6

The Babylonian calendar and its effect on goal-year methods of prediction

6.1 Introduction

The previous chapter investigated the accuracy of the Goal-Year periods and showed that small, regular corrections of a few days needed to be added or subtracted from these periods in order to predict the dates of planetary events accurately. We now need to investigate the effect of intercalation within the Babylonian calendar on Goal-Year methods of predicting phenomena.

Recall that the Babylonian calendar is a luni-solar calendar, where the lunar months were kept in line with the seasons by adding an additional thirteenth month in certain years.[200] During the Seleucid Era, the 19-year intercalation scheme now known as the Metonic cycle was used to determine which years would contain an intercalary month. Intercalary months would invariably be added in the following pattern: an additional month VI_2 (following Month VI) in year 1, and additional month XII_2 (following Month XII) in years 3, 6, 9, 11, 14 and 17.

For convenience, year 1 of the Metonic cycle is taken to be the year containing the additional Month VI_2; this is essentially arbitrary.[201] This year 1 corresponds to years 18, 37, 56, etc, of the Seleucid Era, and every 19th year thereafter. The Metonic cycle was used without alteration for the entire Seleucid Era, and there is no evidence of deviation from this pattern of intercalary months in any of the extant Goal-Year Texts, Normal Star Almanacs or Almanacs.

6.1.1 Goal-Year periods

As Chapter 4 showed, Goal-Year type planetary periods in the procedure texts are always expressed textually as a whole number of Babylonian years (occasionally with a date or longitude correction). However, as we know, the Babylonian year may contain either 12 or 13 months and is therefore not a constant unit of time. This implies that a Goal-Year period is not a constant length when expressed in years: it may sometimes end up being a month shorter or longer than the true period over which the planet's events recur.

It is more helpful to think of the Goal-Year periods in terms of lunar months. Table 6.1 summarises the planetary periods from the Goal-Year Texts, which were used by the Babylonian astronomers for the recurrence of planetary events. The table also shows the planets' theoretical periods expressed in terms of lunar months.

[200] See Chapter 1's section on "Calendrical Systems".
[201] Neugebauer (1955), p. 33.

Planet (period in Babylonian years)	Event type	Calculated period in lunar (Babylonian) months	Goal-Year period in lunar (Babylonian) months
Mercury (46)	both	569 months - 1 day	568 or 569
Venus (8)	phenomena	99 months - 3 days	98 or 99
Venus (8)	passages	99 months - 1 day	98 or 99
Mars (79)	phenomena	977 months + 6 days	977 or 978
Mars (47)	passages	581 months + 14 days	581 or 582
Jupiter (71)	phenomena	878 months + 1 day	878 or 879
Jupiter (83)	passages	1027 months - 7 days	1026 or 1027
Saturn (59)	phenomena	730 months - 6 days	729 or 730
Saturn (59)	passages	730 months - 15 days	729 or 730

Table 6.1: A reminder of the planetary periods used in the Goal-Year Texts, expressed as lunar months plus or minus a number of days. The date corrections are the theoretical modal corrections calculated in Chapter 4.

As Table 5.1 in the previous chapter showed, the number of Babylonian years spanned by a Goal-Year period could contain two different numbers of lunar months; the exact planetary period always falls between these two numbers. For example, events involving Mercury recur after almost exactly 569 months. In cases where the 46-year Babylonian Goal-Year period spans 569 months, the event will take place during the same month in both the goal year and the observation year. However, 46 Babylonian years can sometimes span only 568 months and, when this is the case, the event will occur a month later in the goal year than it did in the observation year.

Conversely, Jupiter's planetary phenomena recur after almost exactly 878 months. When the 71-year Goal-Year period is 878 months long, the event will again take place during the same month in the goal year and the observation year. However, 71 Babylonian years can also be 879 months long. When this is the case, the event will occur a month earlier in the goal year than it did in the observation year.

Here I have defined the term "month shift" to refer to the date of a predicted event being changed by exactly one month to correct for the varying length of the Goal-Year period. It is important to clarify that this does not take into account whether the month changes due to the few days' correction to the Goal-Year period shown in Table 6.1. Sometimes adding or subtracting a few days to the date of an observation can result in the predicted event being expected in a different month, when the observation date was close to the beginning or end of a month, but this correction is entirely independent of the month shift. In cases where the month shift was necessary, two corrections would be independently applied to the date: the few days' correction would be added or subtracted and the expected event date would be moved forward or backwards by one month. In this chapter, we are only interested in the effect of the month shift.

To know when exactly this month shift would be necessary, we need to know what the pattern of intercalary months is near the year for which we would like to make predictions. It is clear that what affects the length of a Goal-Year period in lunar months is how many intercalary months fall within it. In other words, whether a month shift is needed depends on where the goal year falls within the Metonic cycle.

6.1.2 How often is the month shift necessary?

In the 19 years of the Metonic cycle there are 235 lunar months. For each of these 235 months, for each Goal-Year period, we can count forward the number of lunar months after which the planet's events recur (column three of Table 6.1). From this we can

determine how often the observed and predicted events are expected in equivalent months, and in how many cases a month shift would be necessary. Table 6.2 summarises this for each planet, showing that a month shift is necessary around 21% of the time. However, the frequency of month shifts varies greatly by planet: for Mercury and Venus, a month shift is hardly ever necessary (only 6% of the time), while for Jupiter's Normal Star passages a month shift is needed 44% of the time.

Planet (period in Babylonian years)	Event type	Number of months where: No month shift needed	Month shift needed
Jupiter (71)	phenomena	195	40
Jupiter (83)	passages	132	103
Venus (8)	both	221	14
Mercury (46)	both	221	14
Saturn (59)	both	169	66
Mars (79)	phenomena	208	27
Mars (47)	passages	156	79
Totals		1302	343
Percentage of months needing a correction:			20.85%

Table 6.2: The number of months in the 19-year Metonic cycle which require a month shift when using the Goal-Year periods.

6.1.3 What patterns are there to the month shifts?

Having established that a month shift is needed around 21% of the time, the next step is to see what patterns there are in the distribution of month shifts within the Metonic cycle. Table 6.3 shows for each year of the Metonic cycle, for each planet, how many months are "different" (i.e. a month shift is needed) between the observations year and the goal year. A more detailed version of this table showing each month separately is given in Appendix H.

To illustrate this: if the goal year is year 1 of the cycle, a month shift would be seen in Months VI_2 to XII of the goal year (but not in Months I to VI) when predicting Jupiter's or Mars' Greek-letter phenomena, or Mars' Normal Star passages. A month shift would be seen in Months I to VI_2 of the goal year (but not in Months VII to XII) for Jupiter's Normal Star passages, or for events involving Venus, Mercury, or Saturn.

Year of Metonic Cycle	Jupiter phenomena		Jupiter passages		Venus all events		Mercury all events		Saturn all events		Mars phenomena		Mars passages	
1**	last	7	first	7	first	7	first	7	first	7	last	7	last	7
2		0		0		0		0		0		0		0
3*	last	1	all	13		0		0	last	7	last	1	last	1
4	all	12		0		0		0		0	first	6	all	12
5		0		0		0		0		0		0		0
6*		0	all	13		0		0	all	13		0	last	1
7		0		0		0		0		0		0	all	12
8		0	last	6		0		0		0		0		0
9*		0	all	13	last	7	last	7	all	13		0	last	1
10		0		0		0		0		0		0	first	6
11*	last	1	all	13		0		0		0	last	1	last	1
12	all	12		0		0		0		0	all	12	all	12
13		0		0		0		0		0		0		0
14*	last	1	all	13		0		0	all	13		0	last	1
15	first	6		0		0		0		0		0	all	12
16		0		0		0		0		0		0		0
17*		0	all	13		0		0	all	13		0	last	1
18		0		0		0		0		0		0	all	12
19		0	all	12		0		0		0		0		0

Table 6.3: Number of months where predictions made using the Goal-Year periods will occur in a *different* month from the observation year

We can see from Table 6.3 that, for any particular year, there are four types of month distribution:

i) All (12 or 13 months) the same. This is the simplest, and most common, case – each month of the observation year predicts events for the same month of the goal year; no month shifts are necessary. If the goal year is year 2, 5, 13 or 16 of the Metonic cycle, no month shifts are necessary for any of the planets.

ii) Half the year (6 or 7 months) the same, and half the year different. This occurs when either the observation year or the goal year contains a Month VI_2. Since none of the Goal-Year periods is of the right length that both the observations year and the goal year can contain a Month VI_2 at the same time, obviously a month shift will always be necessary for half of the year in this case due to the extra month being added into the middle of one of the years.

iii) 12 months the same and one different. This can happen when, for example, the observation year only has 12 months but the goal year has 13. If Month I of the observation year predicts Month I of the goal year, and so on up until Month XII predicts Month XII, then to predict Month XII_2 of the goal year requires the month after Month XII of the observation year, which is of course Month I of the following year.

iv) All (12 or 13 months) different. This type of distribution quite often follows on from type iii) – if Month I of an observation year has been used to predict the last month of a goal year, then Month II of the observation year will predict Month I of the next goal year, and so on, with all the dates being shifted backwards by one month. The month shift can also happen the other way round: sometimes Month I of the observation year predicts Month II of the goal year, and all the months needing to be shifted forwards instead. In this case, to predict Month I of the goal year we will need Month XII or XII_2 from the end of the year *before* the observation year.

Putting all of this together will allow an "instruction manual" to be built up of when month shifts are necessary for any or all of the planets during any particular goal year. While it is impossible to prove exactly what methods the Babylonian astronomers used, this can be used to show whether the dates of Babylonian predictions demonstrate the month shifts at the expected points.

6.2 Evidence from Babylonian sources

6.2.1 A comparison of the dates of observations and predictions of planetary data

It is now necessary to go to the Babylonian source material to investigate how the Babylonian astronomers took account of the month shifts in their predictions. A useful method of doing this is to look at the records in the same way as they would have been used by the astronomers: looking for examples of month shifts between the records in an Almanac or Normal Star Almanac and those in the Astronomical Diaries from one Goal-Year period back.

For an example of how to put this into practice, let us take the Normal Star Almanac for the year SE 189. Looking at the Astronomical Diaries for one Goal-Year period earlier for each planet, we find that only three useful Diaries are extant: those covering the years SE 118, for Jupiter's Greek-letter phenomena; SE 181, for Venus's Greek-letter phenomena and Normal Star passages; and SE 143, for Mercury's Greek-letter phenomena and Normal Star passages.

SE 189 has an intercalary month VI_2 making it year 1 of our reference Metonic cycle.

From Appendix H, we see that for Mercury and Venus we expect to find the following month shifts:

Observation month	predicts	Goal-Year month
XII_2 (of previous year)		I
I		II
II		III
III		IV
IV		V
V		VI
VI		VI_2
VII-XII		VII-XII (no shift necessary)

Comparing the records in the texts, we find the following:

> 27 GU_4-UD *ina* ŠÚ[sic] *ina* ABSIN IGI … *in* 25 IGI
> "The 27th, Mercury's first appearance in the <east> in Virgo … (ideal) first appearance on the 25th."
> (*ADART* Vol II No. -168A, Obv. 12, Month **V**.)

> 25 GU_4-UD *ina* NIM *ina* ABSIN IGI
> "The 25th, Mercury's first appearance in the east in Virgo."
> (LBAT **1055, Obv. 37-38 (Normal Star Almanac for SE 189), Month **VI**.)

Here we see the expected month shift.

> GE_6 11 *ina* ZALÁG G[U_4-UD SIG] DELE *šá* IGI ABSIN 1 KÙŠ 8 SI ...
> [23 GU_4-UD] *ina* NIM *ina* (SAG) RÍN ŠÚ
> "Night of the 11th, last part of the night, Mer[cury was] 1 cubit 8 fingers [below] γ Virginis. …
> [The 23rd, Mercury's] last appearance in the east in (the beginning of) Libra."
> (*ADART* Vol II No. -168A, Obv. 19-25, Month **VI**.)

> GE_6 10 *ina* ZALÁG GU_4-UD SIG DELE *šá* IGI ABSIN 1 KÙŠ 8 SI ...
> 23 GU_4-UD *ina* NIM *ina* RÍN ŠÚ
> "Night of the 10th, last part of the night, Mercury 1 cubit 8 fingers below γ Virginis. …
> The 23rd, Mercury's last appearance in the east in Libra."
> (LBAT **1055, Rev. 39-40 (Normal Star Almanac for SE 189), Month **VI_2**.)

Here we see the expected month shift.

> *in* 15? GU_4-UD *ina* ŠÚ *ina* PA IGI
> "Around the 15th? Mercury's first appearance in the west in Sagittarius."
> (*ADART* Vol. II No. -168A, Rev. 10'-11', Month **VIII**.)

14 GU_4-UD *ina* ŠÚ *ina* PA IGI
"The 14th, Mercury's first appearance in the west in Sagittarius."
(LBAT **1055, Rev 48, (Normal Star Almanac for SE 189), Month **VIII**.)

Here no month shift was necessary.

in 2 GU_4-UD *ina* ŠÚ [*ina* MÁŠ ŠÚ]
"Around the 2nd, Mercury's [last appearance] in the west [in Capricorn]."
(*ADART* Vol. II No. -168E, Obv. 2-3, Month **IX**.)

2 GU_4-UD *ina* ŠÚ *ina* MÁŠ ŠÚ
"The 2nd, Mercury's last appearance in the west in Capricorn."
(LBAT **1055, Rev 51, (Normal Star Almanac for SE 189), Month **IX**.)

Here no month shift was necessary.

[…] USAN *dele-bat* SIG MÚL-MÚL 1 ½ KÙŠ
"[Night of the 15th] first part of the night, Venus was 1 1/2 cubits below η Tauri."
(*ADART* Vol. III No. -130D, Rev. 12, Month **XII**.)

GE_6 13 USAN *dele-bat* SIG MÚL-MÚL 1 ½ KÙŠ
"Night of the 13th, first part of the night, Venus 1 1/2 cubits below η Tauri."
(LBAT **1055, Rev. 68, (Normal Star Almanac for SE 189), Month **XII**.)

Here no month shift was necessary.

While, for Jupiter, we expect to find the following month shifts:

Observation month	predicts	Goal-Year month
I-VI		I-VI (no shift necessary)
VII		VI_2
VIII		VII
IX		VIII
X		IX
XI		X
XII		XI
XII_2		XII

And, comparing the texts again, we find the following:

25 MÚL-BABBAR *ina* MAŠ-MAŠ ŠÚ
"The 25th, Jupiter's last appearance in Gemini."
(*ADART* Vol. II No. -193A, Rev. 3', Month **II**.)

25 MÚL-BABBAR *ina* MAŠ-MAŠ ŠÚ
"The 25th, Jupiter's last appearance in Gemini."
(LBAT **1055, Obv. 12, (Normal Star Almanac for SE 189), Month **II**.)

Here no month shift was necessary.

in EN 26 MÚL-BABBAR *ana* ŠÚ *ki* UŠ-[a …]
"Around the 26th, when Jupiter became stationary to the west [error for east …]"
(*ADART* Vol. II No. -193B, Obv. 10', Month **VII**.)

26 MÚL-BABBAR *ina* TIL MAŠ- MAŠ UŠ
"The 26th, Jupiter stationary in the end of Gemini."
(LBAT **1055, Rev. 44, (Normal Star Almanac for SE 189), Month $\mathbf{VI}_2$.)

Here we see the expected month shift.

[*in*? E]N 24 MÚL-BABBAR *ana* ŠÚ *k*[*i* UŠ-a …]
"[Around?] the 24th, [when] Jupiter [became stationary] to the west […]"
(*ADART* Vol II No. -193D, Rev. 15', Month **XI**.)

24 MÚL-BABBAR *ina* MAŠ-MAŠ UŠ
"The 24th, Jupiter stationary in Gemini."
(LBAT **1055, Rev. 58, (Normal Star Almanac for SE 189), Month **X**.)

Here we see the expected month shift.

In every case, the predicted events follow the expected pattern: month shifts are found at the points where we would expect them to have been necessary, and are not found at the points where we would expect them to have been unnecessary.

We can also compare months of predicted events with observational data from Goal-Year texts, given that (as shown in §2.7) these texts appear to have been compiled directly from Diary observations. From this we can ascertain whether the month shift was added in at the point when the Diary records were copied into the Goal-Year texts, or, as with the date corrections, at the point when the records were copied from the Goal-Year texts into the Almanacs or Normal Star Almanacs.

Below are some examples of record comparisons between the Diaries, Goal-Year Texts and the predictive texts.

[… EN 23 AN *ana* ŠÚ *ki* UŠ-a nn mm *ár* MÚL TUR *šá* 4 KÙŠ] ⌜*ár*⌝ LUGAL …
"[Around the 23rd, when Mars became stationary to the west, it became stationary … behind ϱ Le]onis …"
(*ADART* Vol. II No. -261B, Rev. 5', Month **XII**.)

EN 23 AN *ana* ŠÚ *ki*-⌜*i*⌝ [...]
"Until the 23rd, when Mars [became stationary] to the west..."

(*ADART* Vol. VI No. 27, Obv. 33, (Goal-Year Text for SE 129, observational data from year SE 50), Month **XII**.)

[…] AN *ina* A UŠ
"[23-28th…], Mars stationary in Leo"
(LBAT **1123, Rev. 3, (Almanac for SE 129), Month [**XII**].)

Here no month shift was necessary.

18 GENNA *ana* M[E E-*a*]
"The 18th, Saturn's acronychal rising."
(*ADART* Vol. II No. -263, Obv. 14'. Month **IX**.)

in 18 GENNA *ana* ME E-*a*
"Around the 18th, Saturn's acronychal rising."
(*ADART* Vol. VI No. 18, Obv. 5' (Goal-Year Text for SE 107, observational data from year SE 48), Month **IX**.)

13 GENNA *ana* ME E-*a*
"The 13th, Saturn's acronychal rising."
(LBAT 1016, Rev. 3', (Normal Star Almanac for SE 107), Month **X**.)

Here there is no month shift between the Diary observation and the Goal-Year Text record, but we see the expected month shift when comparing the Goal-Year Text and the Normal Star Almanac.

This shows that the month shift was added in when necessary *after* the Goal-Year text was created – i.e. in using the Goal-Year Text to produce the Almanac or Normal Star Almanac. This is consistent with the findings of Chapter 5, which showed that the date correction would have been added when using the Goal-Year Text to produce the Almanac or Normal Star Almanac, rather than when the Diary records were copied into the Goal-Year text.

However, this is inconsistent with the practice concerning lunar records. It has been shown that, where a month shift was necessary for the 18-year lunar period, Lunar Six values were occasionally recorded in the Goal-Year Text under the predictive month rather than the month in which they were observed.[202] This relabelling has only been found in Goal-Year Texts for years prior to SE 118. In other words, for Lunar Six events before this date, the month shift was applied when copying the Diary records into the Goal-Year Text. There is no evidence of this practice ever occurring in the planetary sections of Goal-Year Texts.

This means that, for planetary events, the month of an event recorded in the Goal-Year texts is always the month in which the event was observed, rather than the month of the event to be predicted (when these months differed). When looking for month shifts, we can therefore treat records from Goal-Year texts as being in the same dataset as records from Diaries.

The observational records from the Diaries and Goal-Year texts were compared with those from the Almanac or Normal Star Almanac one Goal-Year period later, to find

[202] Brack-Bernsen (1999b), Gray & Steele (2009).

evidence of month shifts. Table 6.4 summarises the results of these comparisons, showing, for each planet, how many of the record comparisons demonstrated a month shift and how many did not. Full details of the records used for this comparison can be found in Appendix I.

	Number of records showing:			
	No month shift (expected)	Month shift (expected)	Month shift (unexpected)	Total
Jupiter (71)	25	3	1	29
Jupiter (83)	1	1	0	2
Venus (8)	65	1	0	66
Mercury (46)	92	7	0	99
Saturn (59)	18	6	0	24
Mars (79)	17	1	0	18
Mars (47)	24	6	0	30
Total	242	25	1	268

Table 6.4: A summary comparing planetary data from Astronomical Diaries and Goal-Year Texts with Almanacs and Normal Star Almanacs, to look for evidence of month shifts in the record dates.

The table shows that the Babylonian records fit in with our theoretical pattern of month shifts extremely well. For all the predictions of events during months where we have shown that a month shift would be necessary, the expected month difference is found between the observational record and the predictive record of the event. Likewise, in all but one of the cases where we have shown that a month shift would *not* be necessary, no month difference is found between the observational and the predictive record. There is only one anomaly to address: for one prediction of a Jupiter phenomenon, the records seem to show a month shift in a place where we would not expect it. This involves the Diary for year SE 174, and the Almanac for SE 245.

> […] MÚL-BABBAR *ina zib*^{me} ŠÚ
> "[…] Jupiter's last appearance in Pisces."
> (*ADART* Vol III No. -137E, Rev. 5'. Month **XII**.)
>
> 25 MÚL-BABBAR *ina zib*^{me} ŠÚ
> "The 25th, Jupiter's last appearance in Pisces."
> (LBAT *1179-80, rev. 22, (Almanac for SE 245), Month **XI**.)

At first glance, this seems like an unnecessary month shift. However, calculations show that Jupiter's last visibility should have taken place around day 29 of Month XI in SE 174, and around day 28 of Month XI in SE 245; no month shift was necessary in this case.[203] Therefore it is the *observation* which shows the "wrong" date; were this just a case of an incorrectly applied month shift, we would expect to see a correct observation date leading to an incorrect prediction date.

For the Diary record, the day of the event is broken away and the record comes from an end of the month summary, preventing us from deducing when in the month it was observed. The most simple explanation therefore seems to be that the phenomenon could have been observed in SE 174 at the very beginning of Month XII, only a day or two away

[203] These dates are taken from Roughton's theoretical tables of event dates – see §1.4.3 as before.

from the calculated approximate date of Month XI day 29. It may then seem odd that the predicted date of the event in SE 245 would then be several days earlier than the observed date in SE 174, given that the dates of Jupiter's phenomena do not usually need to be corrected between one Goal-Year period and the next (see Table 6.1). Perhaps it was cloudy around the time of Jupiter's disappearance, and the Babylonian astronomers decided that the planet's last visibility would actually have been a few days earlier than they recorded? We cannot be certain. Nevertheless, it seems most probable that this discrepancy should not be considered an erroneous month shift.

Again, we cannot conclude from this anything about the methods the Babylonian astronomers may have used kept track of when a month shift was or was not necessary. All we can conclude from the data is that they were aware of the need for month shifts when making predictions, and when to apply them.

6.2.2 Reports of intercalary months in the planetary sections of the Goal-Year Texts

Some evidence for ways in which the Babylonian astronomers kept track of the calendrical system may be found in the Goal-Year Texts. In the planetary observations sections we find the occasional note that the observation year, or the year previous to it, was intercalary. This note is not connected to a specific observation, but instead appears to be purely calendrical in character. For example, consider the goal year SE 106:

> Jupiter's Greek-letter phenomena, observation year = SE 35:
>
> MU-34-KAM ŠE DIR MU-35-KAM ^{I}*An-t*[*i-'u-uk-su u* ^{I}*S*]*e-lu-ku* LUGAL^{meš}
> "Year 34: month XII was intercalary. Year 35, kings Ant[iochus and] Seleucus."
> (followed by records for SE 35 as normal)
> (*ADART* Vol VI No. 15, Obv. 1 (Goal-Year Text for SE 106))

> Jupiter's Normal Star passages, observations year = SE 23:
>
> MU-23-KAM ^{I}*Se-lu-ku u* ^{I}*An-ti-'u-*[*uk-su* LUGAL^{m}]^{eš}
> "Year 23, [kings] Seleucus and Antiochus."
> (records for SE 23 as normal, followed by)
> ŠE DIR
> "Month XII was intercalary."
> (*ADART* Vol VI No. 15, Obv. 4 and 7 (Goal-Year Text for SE 106))

Also of interest are the Goal-Year Texts where planetary observations are included for not only the observation year, but also sometimes the end of the preceding year or the beginning of the following year. For example, consider the goal year SE 118:

> Jupiter's Normal Star passages, observations year = SE 35:
>
> MU-34-KAM ^{I}*An-ti-'u-uk-su u* ^{I}*Se-lu-ku* LUGAL^{meš} DIR-ŠE GE_6 22 USAN MÚL-BABBAR *e šur* GIGIR *šá* ULÙ ½ KÙŠ
> "Year 34, kings Antiochus and Seleucus. Month XII_2, night of the 22nd, first part of the night, Jupiter was ½ cubit above ζ Tauri."

(records for SE 35 as normal, followed by)

MU-36-KAM BAR GE_6 1[?] ⌜USAN MÚL-BABBAR *ana* NIM *ina*⌝ [LAL-*šu*] SIG MAŠ- MAŠ *ár* 2 KÙŠ
"Year 36. Month I, night of the 1st[?], first part of the night, Jupiter, while moving back to the east, was 2 cubits below β Geminorum."
(*ADART* Vol VI No. 20, Obv. 5 and 8 (Goal-Year Text for SE 118))

In total 20 Goal-Year Texts include a remark that an observation year was intercalary (that is, specifically using the phrasing "Month XII was intercalary" rather than any references to events within the intercalary month), and 16 record that the year before the observation year was intercalary. 10 include records for the month XII or XII_2 of the year before the observation year, and 13 include records for Month I of the year following the observation year. Full details of which texts included these records are available in Appendix J.

The frequency of these "Month XII was intercalary" remarks is much too low for them to have been included as a matter of course for every intercalary month, even taking into account that some of the now-damaged texts may once have contained more such entries. Instead, we can test whether the remarks may have been connected with the issue of month shifts. There are four types of remarks to explain:

i) Records of events occurring within Month XII or XII_2 of the year before the observation year. These all occur at points where either a month shift was necessary, or a correction to the date meant that these records from the previous year were needed to predict Month I of the goal year.

ii) Records from Month I of the year following the observation year. All of these cases involve records in the first few days of Month I, where the necessary correction subtracted a few days (again, refer to Table 6.1 for these corrections) and hence would put the records within the goal year. None of these records are due to a month shift.

iii) A remark that the observation year had an intercalary month. It seems believable that these remarks are to keep track of the calendar by ensuring that the intercalary months are noted whether or not there are any planetary events recorded for the month. The presence of a "Month XII was intercalary" remark does not seem to have any connection to whether or not there were any planetary events recorded for the Month XII_2 of that year.

iv) A remark that the year before the observation year had an intercalary month. At first glance it seems that these entries would have been an excellent way to keep track of when a month shift was necessary, particularly for Jupiter and Saturn which move slowly enough that they regularly would have no events of interest occurring within the Month XII or XII_2. However, this explanation is not borne out by the texts. Some of the remarks occur when a month shift would be necessary, but many do not. Similarly, there are many cases where a month shift is necessary and entries of this kind do not occur, even when the previous year was intercalary.

As the Appendix shows, the remarks concerning intercalary months span the entire range of extant Goal-Year Texts, from goal year SE 79 to SE 247. Therefore, this is not evidence of a change in practice over time (as was the case with the relabelling of Lunar Six data) so much as, perhaps, evidence of an inconsistent practice. The Goal-Year Texts were compiled across two centuries, possibly more; we do not know how many people were involved in their creation during that time. The fact that these remarks do not seem to

occur in any particular pattern may just be an artefact of different astronomers' varying preferences concerning how to keep track of intercalary months in the texts. Unfortunately, none of the extant Goal-Year Texts include any information concerning their authors and so this possibility cannot be investigated further.

6.3 Conclusions

I have shown that when using Goal-Year methods to make predictions of planetary or lunar events, the month of the predicted event occasionally needs to be changed due to the calendar system in use. From the analyses presented in this chapter, several conclusions can be drawn about how this problem may have been approached by the Babylonian astronomers.

Firstly, by comparing observational data in the Astronomical Diaries with predictive data in the Almanacs and Normal Star Almanacs, we have seen that the texts contain evidence of the month shifts. These month shifts occur within the records we would theoretically expect to find it, and only in those records. This shows that the Babylonian astronomers were aware of the necessity of month shifts, and knew when to apply them. It does not show in any way how they kept track of which months needed month shifts.

Secondly, comparing observational records in Astronomical Diaries and Goal-Year Texts has shown that, for the planetary data, this month shift was always applied when the Goal-Year Text data was written into Normal Star Almanacs and Almanacs, rather than when the Diary records were written into Goal-Year Texts.

Lastly, by investigating calendrical remarks in the Goal-Year Texts we have seen that these remarks serve several purposes: some are connected with date corrections and month shifts, but not all of them, and the purpose of a lot of the remarks is still unclear. This inconsistent practice could be simply explained by the many scribes who compiled these texts over the centuries employing different practices of record-keeping.

Chapter 7

Mercury's "omitted" visibility phases

As mentioned in Chapter 1, the Goal-Year type texts occasionally make note of an appearance or disappearance of Mercury where the planet was not observed, and in fact was not observable from Babylon, for the entire eastern or western phase. In these records the terminology "UD-DA (IGI/ŠÚ) DIB" is found, in place of the zodiacal sign which would normally be expected in a visibility record. Sachs & Hunger translate this phrase as "first/last appearance …, omitted".[204] DIB, literally translated as "it will pass by", is found alongside similar remarks in records of eclipses which were not observable from Babylon.[205]

However, very few of the researchers into Babylonian planetary theories have written in any detail about *why* the omitted phases occur. For this reason I shall start with a description of the factors which affect Mercury's motion and visibility from Earth, and how these interact, to aid an understanding of why and when the omitted phases happen.

7.1 What factors affect Mercury's visibility?

A planet's visibility is affected by the interaction of several variables, including the planet's elongation from the Sun, its latitude, the angle of the ecliptic to the horizon (which depends on the time of year and the observer's location on Earth), and other factors which cannot be reproduced so easily such as the observing conditions at the horizon on any particular day. Note that one factor which has not been fully analysed in this chapter is Mercury's highly variable apparent magnitude, which can vary between approximately -2 and +5.5 when viewed from Earth. Clearly this will have an important impact on whether or not Mercury can be observed, an impact which will be fully investigated in future work. However, Mercury's variable magnitude is not considered further in this chapter.

The Earth's daily motion means that, relatively, the ecliptic appears to move around it at a constant rate. For a planet which travels with the ecliptic (such as Mercury) to be observable from Earth, it needs to be far enough away from the Sun that it will still be in the sky when the Sun is sufficiently far below the horizon that the sky is dark. In other words, for a morning appearance it needs to rise far enough *before* the Sun, and for an evening appearance it needs to set far enough *after* the Sun.[206] Exactly how far away it needs to be depends on the ecliptic's angle with the horizon: if the ecliptic is relatively perpendicular to the horizon, then arcs of the ecliptic will be seen to rise and set faster: the planet will need a larger elongation (longitude difference) from the Sun to be above the horizon when the Sun is far enough below the horizon.

Conversely, if the ecliptic-horizon angle is comparatively low, then the ecliptic arcs will rise and set relatively slowly – even though the ecliptic is moving at the same speed, less of the motion will be in a direction perpendicular to the horizon. Therefore, for a planet at the same elongation as before, there will be a longer period where the planet is above the horizon but the Sun is far enough below it. The planet can also be spotted when it is at a smaller elongation from the Sun.

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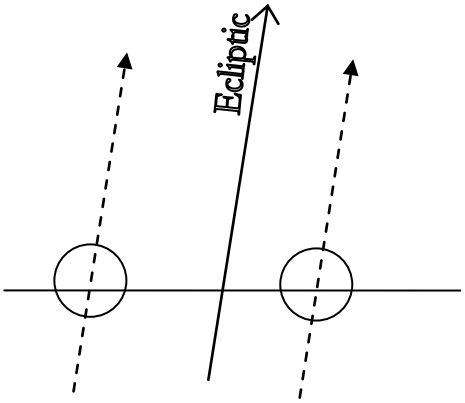
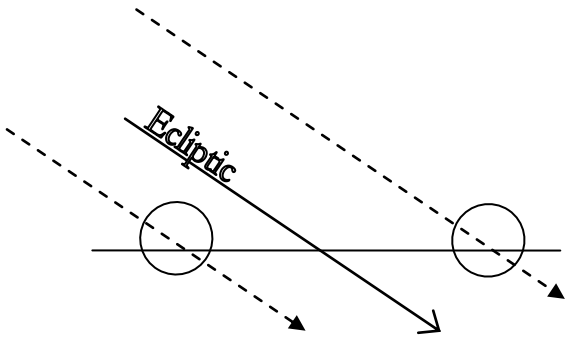
[204] Sachs & Hunger (1988), p. 25.
[205] Steele (2001-2).
[206] The vertical distance below the horizon which the Sun must have reached for the planet to be visible, taking into account these factors of elongation, latitude, etc., is referred to as the *arcus visionus*. See for example Neugebauer (1975), p. 234.

Vernal Equinox



Eastern horizon

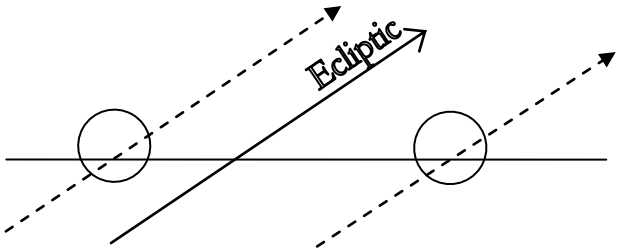
Figure 7.1a: a schematic illustration of Mercury rising with a positive or a negative latitude around the time of the vernal equinox. Note that the ecliptic-horizon angle is at its largest at this time, and so whether Mercury has a positive or negative latitude makes little difference to how long before sunrise it becomes visible.



Western horizon

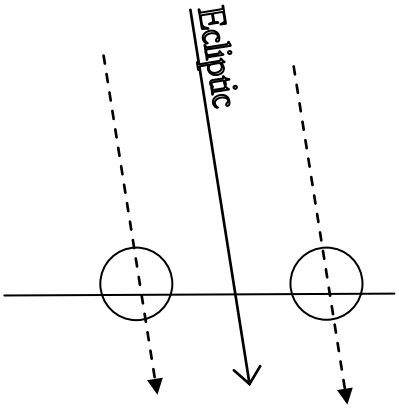
Figure 7.1b: a schematic illustration of Mercury setting with a positive or a negative latitude around the time of the vernal equinox. In this case the ecliptic-horizon angle is at its shallowest, and so Mercury remains visible after sunset for significantly longer when its latitude is positive rather than negative.

Autumnal Equinox



Eastern horizon

Figure 7.1c: a schematic illustration of Mercury rising with a positive or a negative latitude around the time of the autumnal equinox. In this case the ecliptic-horizon angle is again at its shallowest, and so Mercury becomes visible for significantly longer before sunrise when its latitude is positive rather than negative.



Western horizon

Figure 7.1d: a schematic illustration of Mercury setting with a positive or a negative latitude around the time of the autumnal equinox. The ecliptic-horizon angle is again at its largest at this time, and so whether Mercury has a positive or negative latitude makes little difference to how long after sunset it remains visible.

Since Babylon's latitude is approximately 32.5°, the angle between the celestial equator and the horizon is (90-32.5) = 57.5°, and so the angle between the ecliptic and the horizon can vary between 57.5° ± 23.5° (because the Earth's axial tilt is 23.5°). In other words, from Babylon the ecliptic-horizon angle can be a minimum of 34° and a maximum of 81°.

Around the vernal equinox (Month $XII_{(2)}$ or I of the Babylonian year), the ecliptic-horizon angle is at its maximum value at sunrise and at its minimum value at sunset, with the opposite being true around the autumnal equinox (Month $VI_{(2)}$ or VII). (Around the solstices, the ecliptic-horizon angle will of course be around its median value at both sunrise and sunset.) From the above paragraphs, this suggests that Mercury will be observable at a lower elongation (and so will be visible for a longer period) at sunset in Month I and at sunrise in Month VII, than would be necessary at sunrise in Month I and at sunset in Month VII.

However, this is not the full story because we also need to consider the effect of Mercury's latitude. This is illustrated in Figures 7.1a-d, which demonstrates that latitude is much more important when the ecliptic-horizon angle is low. From inspection of Figures 7.1b and c we see that, when the angle is low, a planet with a positive latitude will be above the horizon for a significantly longer length of time than one with a negative latitude. When the latitude is negative, the elongation will need to be much larger for the planet to be above the horizon far enough away from the Sun.

At the other extreme, Figures 7.1a and d show that when the ecliptic-horizon angle is high, a planet's latitude is almost irrelevant because objects at the same longitude rise at almost the same time whether they have a positive or negative latitude. At this point Mercury will rise roughly the same amount of time before the Sun irrespective of its latitude, and so the time difference between Mercury rising and the Sun getting close enough to the horizon for Mercury to disappear will be mostly dependent on Mercury's elongation from the Sun.

To summarise these criteria: Mercury can be seen for the longest when both the ecliptic-horizon angle is low (at sunset in Month I and sunrise in Month VII) *and* it has a high latitude. It can be seen at smaller elongations under these conditions than any others, so its periods of visibility will be longer. When the ecliptic-horizon angle is large (at sunrise in Month I and sunset in Month VII), Mercury will need to be at a larger elongation in order to be seen. However, it can be seen at a much lower latitude than in the previous case where a high latitude was important.

The omitted phases are invariably those which would occur shortly after the vernal equinox (for morning phases) and around the autumnal equinox (for evening phases) – i.e. when the ecliptic-horizon angle is large. Therefore, the omitted phases occur due to this combination of effects: when Mercury's latitude is extremely negative, the ecliptic-horizon angle is large, and Mercury's elongation from the Sun does not reach a large enough magnitude for it to be visible from Babylon. These effects combine to make a complex function for whether or not an appearance of Mercury will "pass by" Babylon. Perhaps this complexity is the reason that very little of the literature offers a reason as to *why* these omitted phases exist, simply taking it for granted that they do.[207]

Sachs & Hunger say that the omitted phases occur "because of unfavourable visibility conditions",[208] a vague turn of phrase with the unfortunate implication, in my opinion, that

[207] The issues are of course very similar to those surrounding visibility of the Moon around conjunction, as discussed and illustrated in, for example, Brack-Bernsen (1999a).
[208] Sachs & Hunger (1988), p. 25.

weather may be preventing the observation. This is not the case, as demonstrated above. In the Astronomical Diaries there is a clear difference of terminology between observations which were prevented because of the weather, which are generally accompanied by a weather description and the remark NU PAP ("I did not watch"[209]), and missed Mercury observations which use the DIB terminology.

The theoretical schemes in *ACT* for calculating Mercury's phenomena include its omitted phases (a fact which reinforces that they are not just an issue of observational technique or adverse weather conditions). As Neugebauer explains, the known Mercury schemes compute certain phenomena by adding on "pushes", or given numbers of days and amounts of longitude, to the values for previously calculated phenomena.[210] Therefore the omitted phases need to be included for the calculations to work, even though they will not be observed. He shows that from the Babylonian astronomers' point of view, whether a phase becomes omitted (in one of the variant schemes, at least), is strongly dependent on Mercury's longitude at the point of first appearance, with morning phases between 10° and 50° longitude, and evening phases between 180° and 215° longitude being omitted.[211] This is consistent with the theory explained above, because Mercury's longitude is strongly linked to the time of year, as is the ecliptic-horizon angle.

However, Neugebauer does not offer at this point any particular explanation of *why* the Mercury phases are not visible. He says, confusingly, that between these longitude points "the phenomena … are so close to each other that they will not be visible at all".[212] Since he does not expand on the remark at this point, one is left with the impression that the phases are omitted due to the calculated first and last visibilities occurring on the same day, perhaps. Again, this is not the case.

Neugebauer's other writings on the subject of computing Mercury's visibilities also discuss these omitted phases, but generally offer little explanation of why they occur. *The Babylonian Method for the Computation of the Last Visibilities of Mercury*[213] confirms the meaning of the terminology which denotes an unobservable phenomenon but, along with *Babylonian Planetary Theory*,[214] does not specifically discuss any of the issues relating to omitted phenomena. *The Exact Sciences in Antiquity* offers a partial explanation, including a figure of an inferior planet's motion relative to the Sun and its phases of visibility and invisibility,[215] and stating that in some parts of the zodiac Mercury "remains so close to the sun that it should be dotted as invisible".[216]

It is not until his *HAMA* that Neugebauer includes an explanation of the issues behind the occurrence of omitted phases, and the mechanics involved.[217] He shows that Ptolemy was aware of the ways in which the effects of Mercury's latitude and elongation and the ecliptic-horizon angle combine to prevent the planet being visible at certain longitudes.[218]

More recent researchers into Babylonian planetary theory have written surprisingly little on this issue. Swerdlow's major work on planetary theory states simply that "there are regions

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[209] The NU PAP terminology was examined in §2.1.1.
[210] See Neugebauer (1955), the section "Theory of Mercury", pp 287-299.
[211] Neugebauer (1955), p. 288; see also pp 366-371, Procedure Text 801.
[212] Neugebauer (1955), p. 367.
[213] Neugebauer (1951).
[214] Neugebauer (1954).
[215] Neugebauer (1969), p. 127.
[216] Neugebauer (1969), p. 132.
[217] Neugebauer (1975), p. 404.
[218] Neugebauer (1975), pp. 239-242, discussing section XIII 8 of the *Almagest* (Toomer 1998, pp. 640-645).

in which an entire morning or evening phase is omitted because the planet does not reach sufficient elongation from the sun to be visible"[219] – true, but far from a complete explanation, as we have seen. Neither Hunger & Pingree's[220] nor Brown's[221] recent works on Babylonian astronomy make anything more than brief references to the omitted phenomena.

Mercury's omitted phases represent an interesting problem in the context of the observational texts. Obviously it is impossible to determine their dates by observation alone; in other words, direct observation cannot distinguish "Mercury is in a period of invisibility" from "Mercury is in a period of visibility which cannot be observed". Diary dates of omitted appearances and disappearances therefore must have been computed.

How might this have been done? In the later part of the period, the omitted dates could have been predicted very easily using the Goal-Year methods described in Chapter 5. As Chapter 4 showed, Mercury's longitudes recur very closely after a 46-year period, and so if one phase is recorded as being omitted then the corresponding phase 46 years later is practically certain to be omitted too. However, the earliest extant observations of omitted Mercury phases date to the early part of the 4th century BC,[222] over 100 years before the earliest extant Normal Star Almanacs.

Some other method must have been used to estimate the earlier dates, and it is possible that inspection of Mercury's Greek-letter phenomena records from the Diaries would have been enough to accomplish this, in a method analogous to the calculation of Lunar Sixes in the Diaries. Recall that compilations of Lunar Six values were available dating back to at least the 7th century BC,[223] and that methods existed allowing values which were not observed to be calculated and added into the Diaries;[224] it seems relatively likely that similar methods could have led to an interested observer working out the details of Mercury's missing phases quite straightforwardly.

Mercury's extremely fast motion means that in a typical Babylonian year it will appear and disappear five or six times, so a complete archive of many years' observations[225] would very quickly contain enough records to gain an understanding of how long Mercury tended to remain visible or invisible in certain phases, and how much its longitude tended to change between one phenomenon and the next. This could easily lead to an awareness that Mercury never became first visible within particular ranges of longitude, and by combining these two pieces of knowledge an observer could regularly check whether Mercury's next expected appearance would be omitted by adding a particular amount of longitude onto an observed last appearance – a crude version of the later *ACT* methods described above.

This does seem to be a plausible way of estimating the dates although it is, of course, speculation on the Babylonian astronomers' methods with no direct evidence. Yet the techniques involved would be entirely in keeping with what we know about their methods in other areas such as the early development of lunar predictions.

The rest of this chapter studies the records in a similar manner as I speculate the

[219] Swerdlow (1998), p. 106.
[220] Hunger & Pingree (1999).
[221] Brown (2000).
[222] The earliest examples are found in *ADART* Vol. V No. 59.
[223] Huber & Steele (2007).
[224] Brack-Bernsen & Hunger (2002).
[225] As was of course available to the Babylonian astronomers in the form of Astronomical Diaries and except texts. The earliest Mercury phenomena excerpts in *ADART* Vol. V are dated to -586 (No. 53).

Babylonian astronomers might have done with the data we know were available to them: by seeing what patterns can be found in the Mercury records. The following sections will examine the records of Mercury's Greek-letter phenomena in the Goal-Year type texts to see what patterns can be deduced in two specific areas: the longitude and latitude dependence of Mercury's appearances and disappearances, and the longitude dependence of the length of Mercury's periods of visibility and invisibility. These patterns can then be compared with the theoretical expectations and the methods from *ACT*.

7.2 Textual evidence of the factors affecting Mercury's visibility phases

7.2.1 Theoretical longitude and latitude dependences

Figure 7.2a-d show the sidereal longitudes and latitudes of Mercury on the theoretical date of each of its Greek-letter phenomena across the Late Babylonian Period.[226] Each figure contains around 1600 data points, covering a period between -600 and 75 AD. As previously stated, it is impossible to determine the exact date of a planet's appearance or disappearance due to observing conditions which cannot be reproduced. However, the criteria which Roughton has used for determining visibility produce a longitude-latitude dependence for Mercury which generally agree with the theory. The figures show that, as expected, Mercury's latitude at the point it first becomes visible depends strongly on its longitude (i.e. it depends on the time of the year and, by extension, the horizon-ecliptic angle, as we have seen). For example, Mercury's latitude at the point it becomes visible in the east shows a maximum value at a longitude of around 240° to 270°; this corresponds to December and early January, i.e. around and after the winter solstice. For Mercury's western phases, the latitude at which it becomes visible shows a maximum value at a longitude of around 70° to 100°; this corresponds to late May and June, i.e. before and around the summer solstice.

Figure 7.2a also shows that Roughton's visibility criteria omit all eastern first appearances between longitudes of around 320° to 55°. This corresponds to the period from mid-March to early June, i.e. around and after the vernal equinox when the ecliptic-horizon angle is at its highest (as we expected). From this we can conclude that Roughton's criteria for being able to view Mercury from Babylon broadly agree with *ACT* (recalling that *ACT* expected morning phases between 10° and 50° longitude to be omitted), but are somewhat stricter.

Figure 7.2c shows that Roughton's visibility criteria omit all western appearances between longitudes of around 190° to 245°. This corresponds to the period from mid-September to early November, i.e. around and after the autumnal equinox when the ecliptic-horizon angle is at its highest (again, as we expected). Recall that the scheme in *ACT* expected longitudes of between 180° to 215° to be omitted; again, Roughton's criteria broadly agree with the *ACT* scheme but set slightly different longitude limits.

Figures 7.2b and 7.2d show that the corresponding theoretical disappearances, between longitudes of 350° and 75° in the east and longitudes of around 190° and 245° in the west, are naturally also omitted.

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[226] Dates taken from Roughton's tables, as before (see Chapter 1). The tropical longitudes have been converted into sidereal longitudes using the correction formula from §3.5.

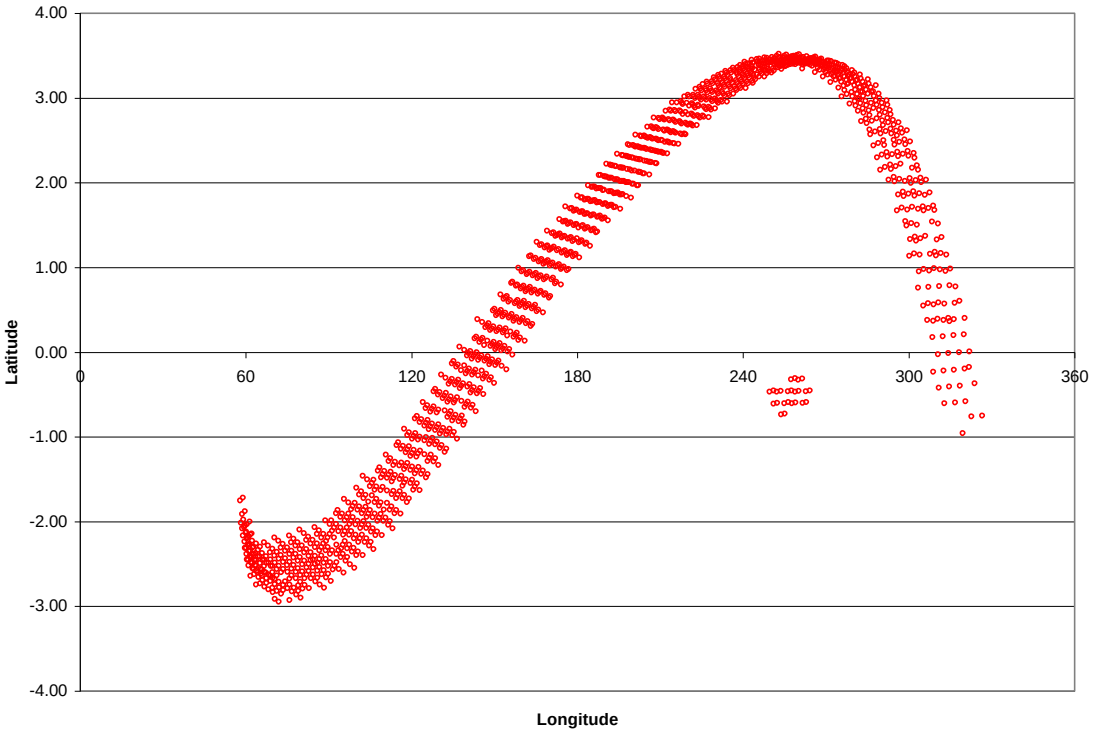

Figure 7.2a: theoretical longitudes/latitudes of Mercury's eastern appearances

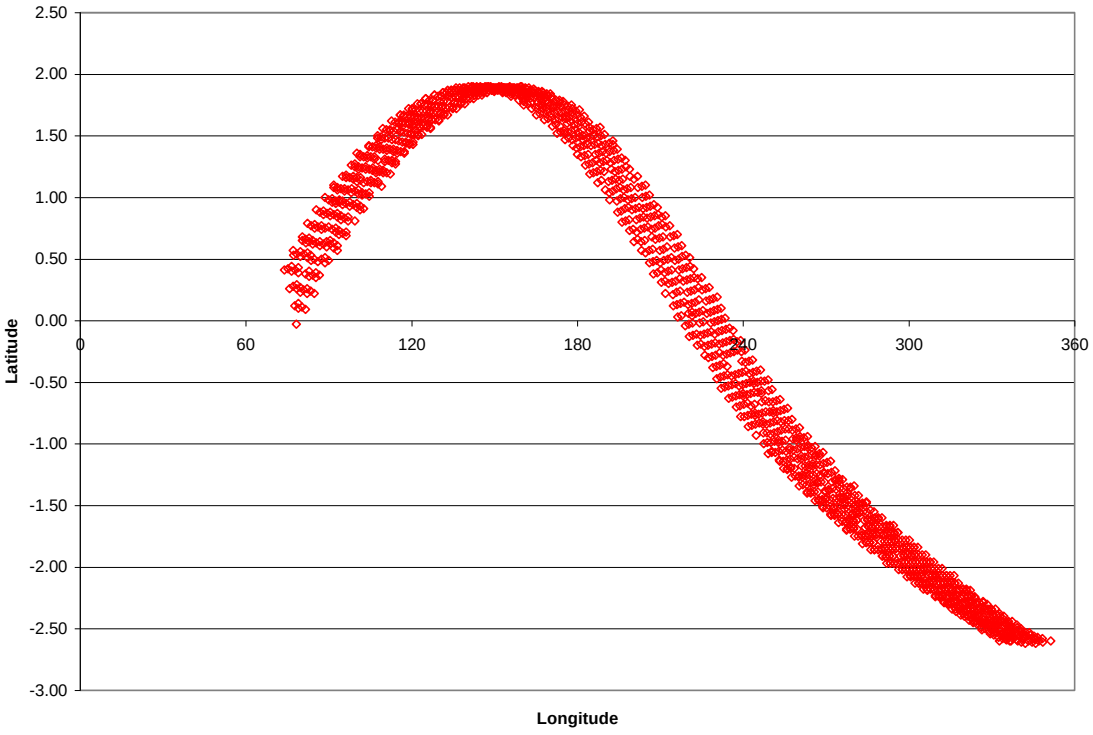

Figure 7.2b: theoretical longitudes/latitudes of Mercury's eastern disappearances

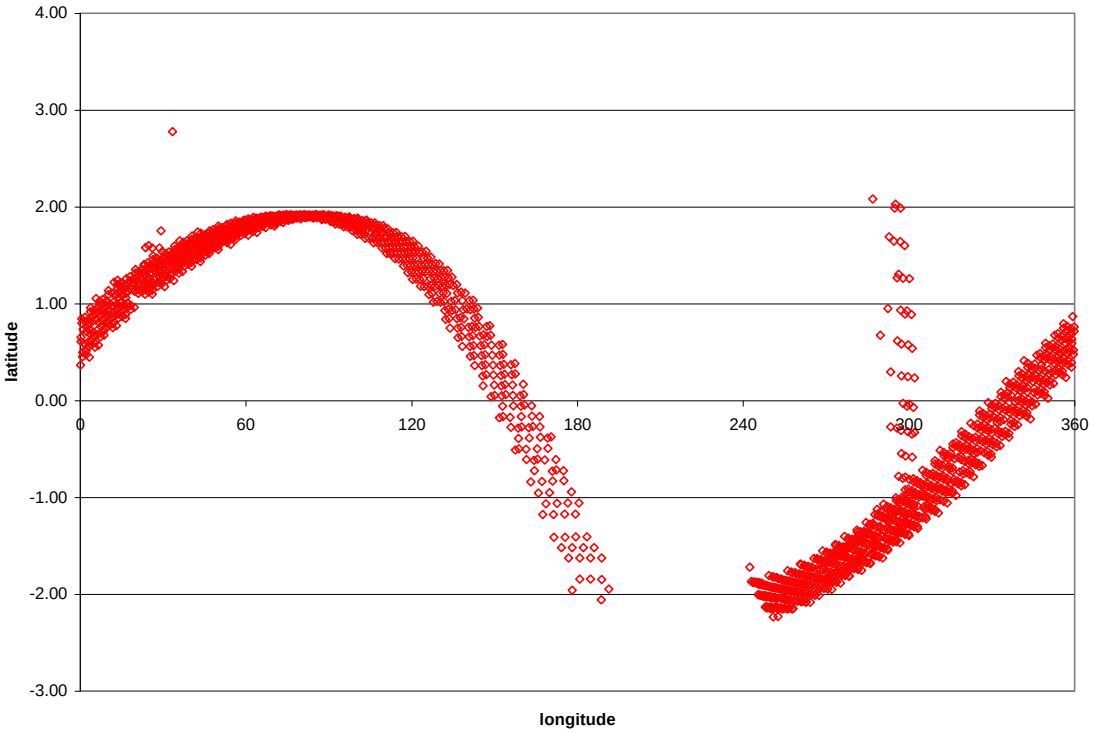

Figure 7.2c: theoretical longitudes/latitudes of Mercury's western appearances

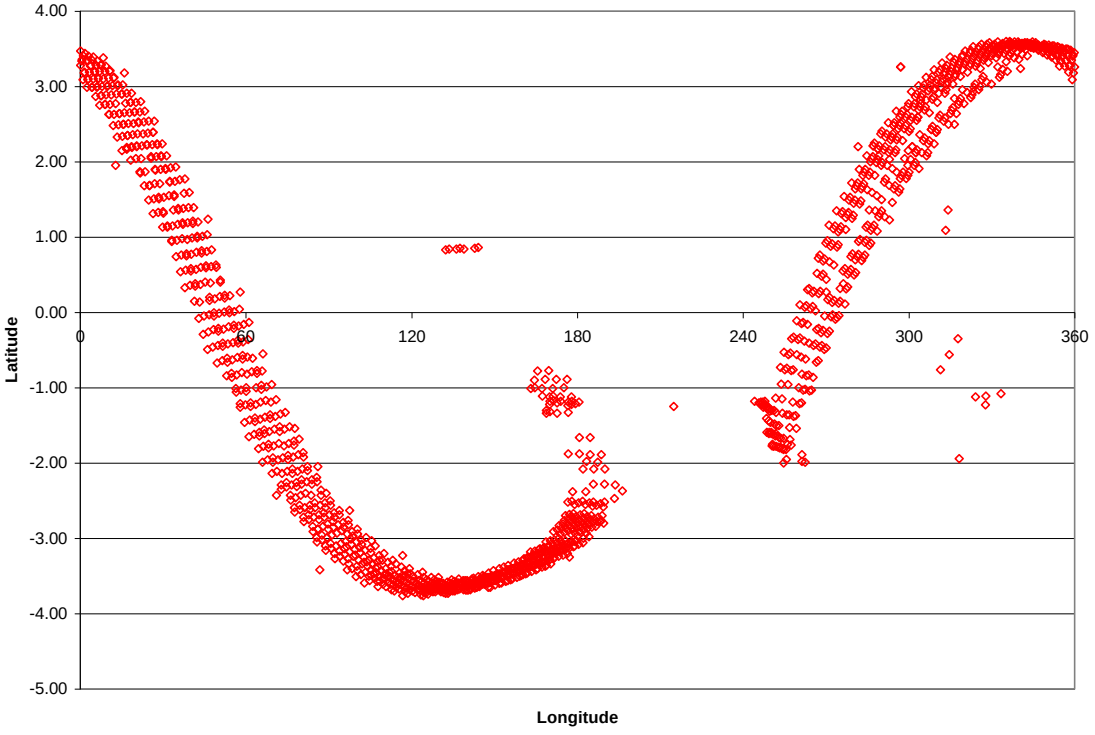

Figure 7.2d: theoretical longitude/latitudes of Mercury's western disappearances

7.2.2 Evidence from the non-mathematical astronomical texts

Having established the theoretical longitude and latitude dependences of Mercury's visibility, the next step is to investigate the observations and predictions in the non-mathematical astronomical texts. The following analysis uses a database (shown in Appendix K) of all records of Mercury's Greek-letter phenomena from *ADART* Vols. I-III, V, VI, and the Normal Star Almanacs and Almanacs listed in Tables 2.7 and 2.8. As before, for each record the Julian date was found[227] and Mercury's longitude and latitude on this date was calculated.[228] Because Mercury's longitude varies so fast, only records with a preserved date (or records where the date could be narrowed down to within a few days) were included.

In the following results, all of the records from the Astronomical Diaries, Goal-Year Texts and *ADART* Vol. V are analysed together as "observations", and all of the records from the Normal Star Almanacs and Almanacs are analysed together as "predictions". Previous chapters have shown that the Vol. V and Goal-Year Text records are excerpts from Diaries, so they all have the same ultimate source and need not be considered separately. Chapter 5 also showed that the records in the Normal Star Almanacs and the Almanacs need not be considered as separate sources of predictions either.

Figures 7.3a-d summarise the longitudes and latitudes of Mercury's observed and predicted Greek-letter phenomena. At this point one must draw attention to the small total number of available records (as usual) – caution must be exercised when trying to deduce gaps in the phenomena's longitude ranges, to check that they are not just a result of the relatively small amount of data. The number of records included in these figures are as follows:

Figure 7.3a (first eastern visibility):
234 observations (of which 32 are recorded as omitted)
45 predictions (of which 4 are omitted)

Figure 7.3b (last eastern visibility):
202 observations (of which 21 are omitted)
42 predictions (of which 5 are omitted)

Figure 7.3c (first western visibility):
231 observations (of which 28 are omitted)
45 predictions (of which 4 omitted)

Figure 7.3d (last western visibility):
223 observations (of which 24 are omitted)
41 predictions (of which 2 are omitted)

Comparing Figure 7.3a with 7.2a, and so on, shows that the longitude/latitude dependence of Mercury's appearances and disappearances in the Babylonian records closely match the theoretical values. As always, the figures contain occasional outlying points which do not fall on the expected curve. Some of these points would fit in with one of the other curves, by assuming that "first" or "east" was an error for "last" or "west", or vice versa. However, as discussed in previous chapters, one must be wary of ascribing too much to the explanation of "scribal error". Therefore, these outlying points have not been "corrected" in any way, beyond double-checking the text of the Babylonian record, the Julian date

[227] Using Parker & Dubberstein (1956).
[228] Using the Bretagnon program, as before (see Chapter 1).

conversion, etc.

The longitude gap of each figure can be estimated in two ways: by showing the range of longitudes over which omitted records occur, and showing the range of longitudes over which non-omitted records are *not* found. Using both of these estimations will help reduce the problem of inaccuracies due to small datasets.

Figure 7.3a shows a maximum latitude of Mercury's first eastern appearances around 250° to 280° (around the time of the winter solstice, as was the case with the theoretical data). The omitted records on this figure all occur between longitudes of 340° to 60°; the non-omitted records show a longitude gap between 345° and 40° except for two clear outliers with longitudes around 15°. These two predictions are from some of the latest known Almanacs which exhibit, as Sachs comments in his translations, some unusual and abbreviated terminology.[229] For example, given his transliteration of the (unbroken) Babylonian record:

> 23 gu_4
> (MM 86.11.354, Obv. 2 (Almanac for SE 342))

Sachs, in his translation of this record, restores the text to say:

> "On the 23rd, Mercury (will be visible for the first time in the east in Aries)"[230]

As the Appendix shows, no other Babylonian record of Mercury's first eastern visibility, observed or predicted, ever takes place in Aries. I have no doubt that these two records were in fact expected to be omitted visibilities and that this discrepancy is simply an artefact of the highly abbreviated terminology in these late texts.

Figure 7.3b shows that the omitted eastern disappearances all occur between longitudes of 350° and 90°, and that the non-omitted records demonstrate a longitude gap between approximately 0° and 60°.

Figures 7.3c again shows that Mercury's latitude at its first western appearance shows a longitude dependence similar to the theoretical values – it reaches its maximum latitude at a longitude of around 70° to 100° (around the time of the summer solstice). The figure shows that the omitted western visibilities all occur between longitudes of 165° to 230°, although three of the points occur at high enough latitudes that one would expect Mercury to actually be visible at these times; if these three values are not included, the omitted points all occur at similar longitudes between 190° and 230°. The non-omitted records show a longitude gap between 190° and 220°.

Figure 7.3d shows that the omitted western disappearances occur between longitudes of 190° and 235°, and that the non-omitted records have a longitude gap between 200° and 225°.

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229 Sachs (1976).
230 Sachs (1976), p. 382.

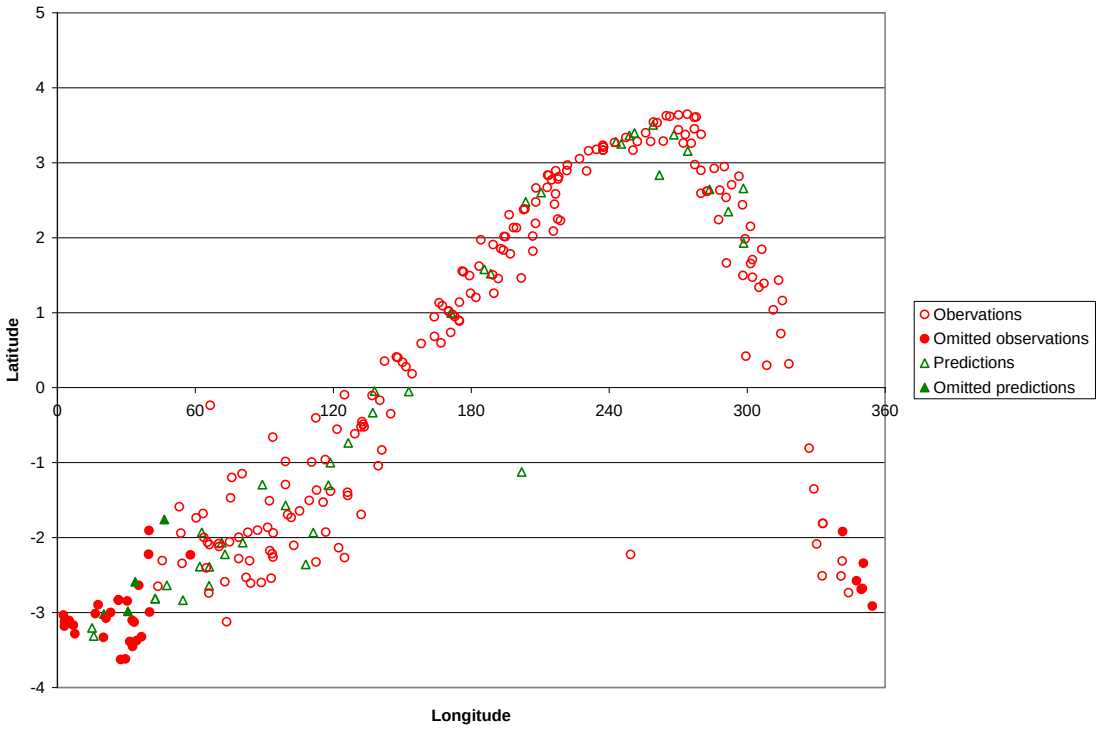

Figure 7.3a: Longitudes and latitudes of Mercury's first eastern appearances, using phenomenon dates from the Babylonian records

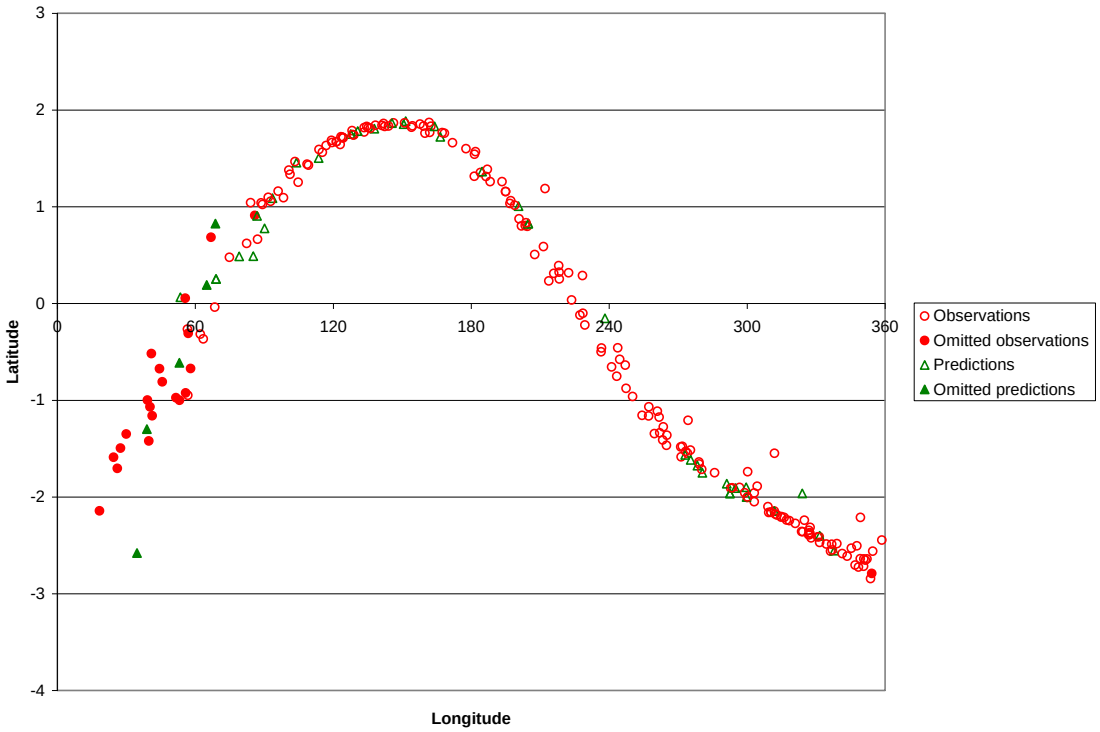

Figure 7.3b: Longitudes and latitudes of Mercury's eastern disappearances, using phenomenon dates from the Babylonian records

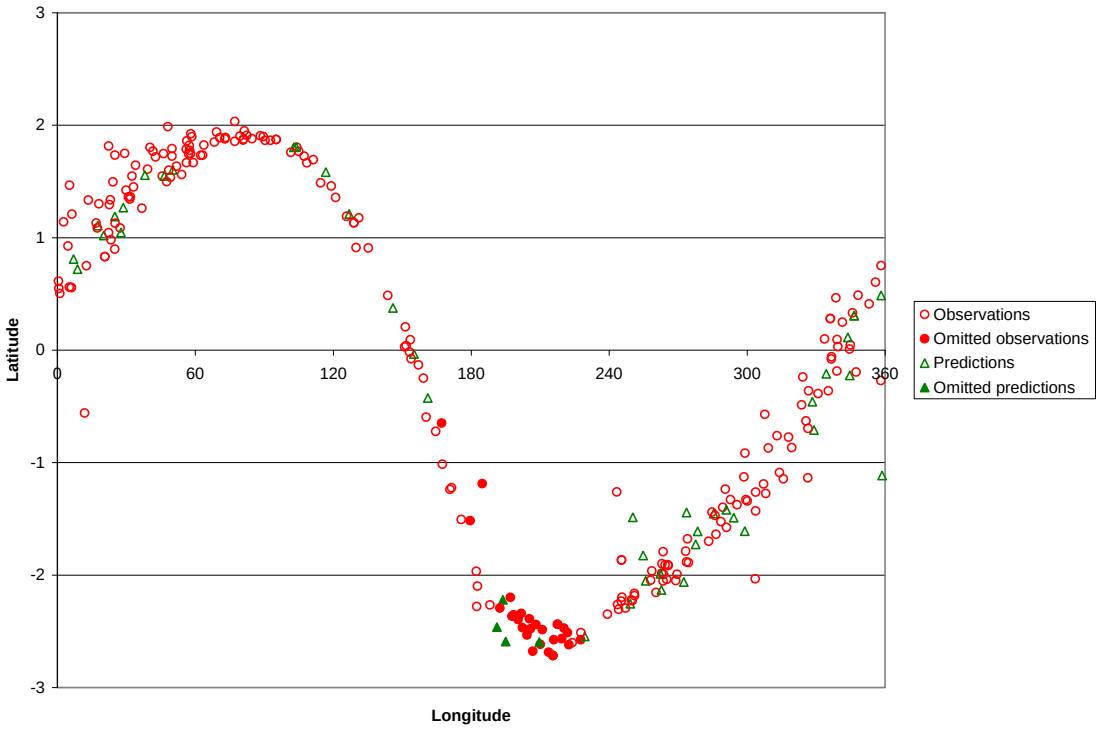

Figure 7.3c: Longitudes and latitudes of Mercury's first western appearances, using phenomenon dates from the Babylonian records

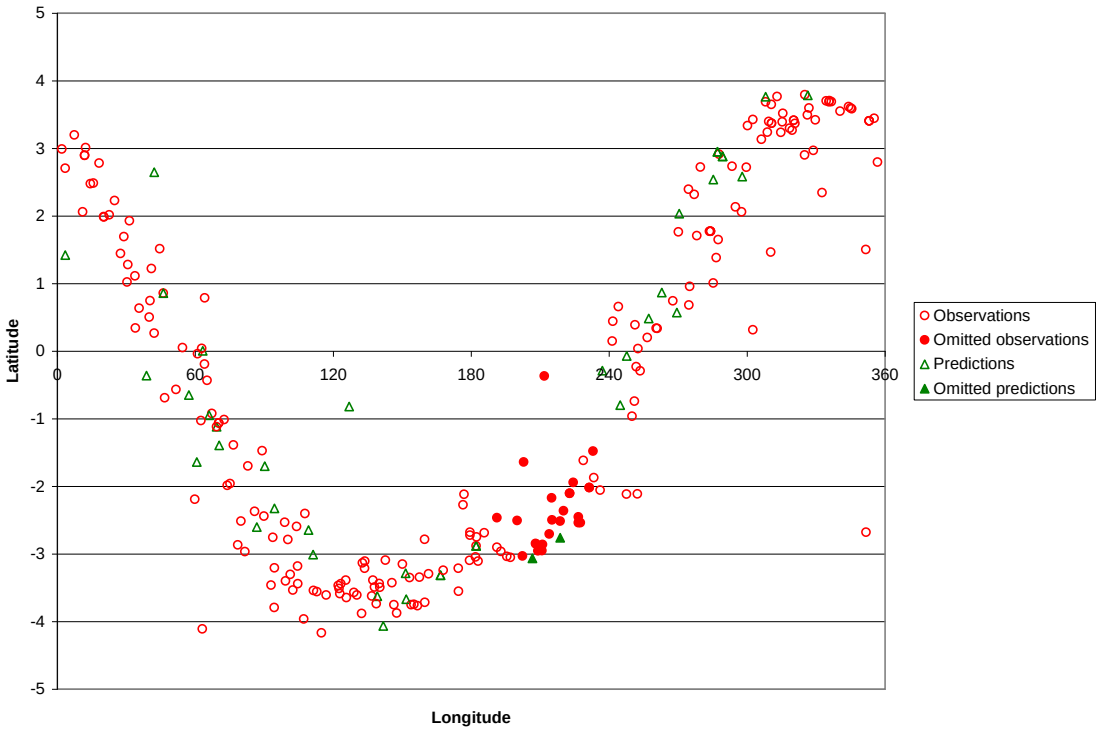

Figure 7.3d: Longitudes and latitudes of Mercury's western disappearances, using phenomenon dates from the Babylonian records

Table 7.1 summarises the results of these figures, to compare the longitude gaps found in the theoretical data (and Figures 7.2a-d), the *ACT* procedure texts, and the Babylonian non-mathematical records (and Figures 7.3a-d). It shows that the circumstances under which omitted phases occur in the non-mathematical texts (i.e. extremely negative latitude and particular times of the year) agree closely with theoretical expectations, and also with the mathematical schemes in *ACT*. The exact boundaries of the omitted regions differ slightly and, as one might expect, in the observational texts there is some overlap between the longitude boundaries of the omitted and non-omitted regions, compared with the precise boundaries of the theoretical schemes.

	Theoretical longitude gaps -		Babylonian non-mathematical records -	
	Roughton's tables	*ACT*	Longitude gap	Omitted longitude range
First eastern visibilities	320° to 55°	10° to 50°	345° to 40°	340° to 60°
Last eastern visibilities	350° to 75°		350° to 90°	0° to 60°
First western visibilities	190° to 245°	180° to 215°	190° to 220°	165° to 230°
Last western visibilities	190° to 245°		200° to 225°	190° to 235°

Table 7.1: a summary of the "omitted" longitude gaps for Mercury's Greek-letter phenomena. The table compares the approximate longitude gaps found in Roughton's theoretical phenomena dates (Figures 7.2a-d above), the *ACT* procedure texts, and the Babylonian records (Figures 7.3a-d above).

The only particular discrepancies concern the fact that the *ACT* schemes tend to underestimate the omitted longitude ranges, compared with the ranges from the non-mathematical observations. For example, *ACT* says that the omitted longitude region for first eastern appearances should begin 10° into Aries. Yet, as we have seen, none of the non-mathematical texts ever record Mercury's first eastern visibility in Aries, and only a very few of them record a first eastern visibility in Pisces. Equally, *ACT* says that the omitted longitude region for first western appearances should end 5° into Scorpio, yet, only an extremely small number of the non-mathematical texts record a first western appearance in Scorpio. This allows one to suggest that omitted dates in the Diaries (and subsequent excerpt texts) were not immediately derived from the same scheme as in *ACT*.

Interestingly, the longitude ranges of the non-mathematical *predictive* records agree much more closely with *ACT*. The longitude ranges are summarised for comparison in Table 7.2. As discussed previously, the two outlying predictions in Figure 7.3a with a longitude around 15° have not been included in this table.

	Theoretical longitude gap - *ACT*	Babylonian non-mathematical predictions -	
		Longitude gap	Omitted longitude range
First eastern visibilities	10° to 50°	300° to 40°	20° to 50°
First western visibilities	180° to 215°	160° to 230°	190° to 210°

Table 7.2: a summary of the "omitted" longitude gaps for Mercury's first eastern and western appearances. This table compares the longitude gaps found from the non-mathematical *predictions* with the *ACT* procedure texts.

It is intriguing that the predictive texts' longitude ranges agree so closely with *ACT* – much more so than the range of omitted longitudes from the observational texts. One might be

tempted to speculate that this is evidence of *ACT*-type methods at work in the compilation of the predictive texts. However, all the previous caveats about speculating from small amounts of data apply here – the predictive texts' omitted longitude ranges are derived from only 4 records in each case. This is simply not enough to draw any conclusions.

7.3 Lengths of Mercury's periods of visibility and invisibility

7.3.1 Evidence from the Astronomical Cuneiform Texts

In *ACT*, Neugebauer outlines the two major systems for computing Mercury's motion. System A_1 involves computing the dates of last visibilities from the dates and longitudes of the previous first visibilities, and System A_2 involves computing the dates of first visibilities from the dates and longitudes of the previous disappearances.[231] These date and longitude "pushes" vary slightly between the different ephemeris texts, but they nevertheless provide a useful comparison with the analysis (in the following sections) of Mercury records in the non-mathematical texts.

Procedure texts 800a-d explicitly tabulate the longitude dependences of Mercury's periods of visibility and invisibility in one variant of System A_1. In the following analyses I have used Neugebauer's System A_1 graphs showing the duration and longitude changes of Mercury's eastern and western visibilities;[232] these are derived from the Procedure texts but use corrected values in place of the obvious scribal errors.[233]

For the duration and longitude changes of Mercury's periods of invisibility, which are not explicitly tabulated in the procedure texts, Neugebauer attempted to derive the approximate relationships from the (much fewer) System A_2 ephemeris texts. I have used his System A_2 graphs showing the duration and longitude changes of Mercury's invisibility following a disappearance in the west,[234] but unfortunately, he does not find enough evidence for a firm restoration of the pushes for Mercury's invisibility following a disappearance in the east.

7.3.2 Evidence from the non-mathematical astronomical texts

Using the same database as above (shown in Appendix K), all cases were found where there were records of two immediately adjacent Mercury phenomena, i.e. the date of an appearance and the following disappearance, or a disappearance and the subsequent reappearance. This leads to the following numbers of record pairs for comparison:

Eastern appearance to disappearance:
109 observations (of which 16 are omitted)
24 predictions (of which 4 are omitted)

Eastern disappearance to western appearance:
88 observations (of which 23 include an omitted date)
19 predictions (of which 2 include an omitted date)

Western appearance to disappearance:

[231] Neugebauer (1955), pp 288-299. There is also a much less well-understood System A_3, attested only in Procedure Text 816.
[232] Neugebauer (1955), p. 294 and 295.
[233] Neugebauer (1955), p. 364.
[234] Neugebauer (1955), p. 298 and 299.

111 observations (of which 11 are omitted)
19 predictions (of which 2 are omitted)

Western disappearance to eastern appearance:
127 observations (of which 23 include an omitted date)
20 predictions (of which 2 include an omitted date)

This is a smaller amount of data than in the above analysis of longitudes and latitudes because it requires finding pairs of adjacent Mercury phenomenon records with preserved dates, which is obviously less likely than finding individual such records. Also note that, for the pairs which involve one eastern and one western record and include an omitted date, the omitted record can naturally be either one of the pair. Which omitted points are eastern and which are western will be clear on the following figures, because of the strong longitude dependence of Mercury's eastern and western omitted visibilities as demonstrated in Figures 7.3a-d.

Figures 7.4a-d show the date differences, and Figures 7.5a-d show the longitude differences, between adjacent Mercury phenomena compared with Mercury's longitude at the time of the *earlier* phenomenon in each case (the same way in which the graphs in *ACT* are structured). The results from the observational and predictive Goal-Year type texts are shown, as before, along with the expected results from the *ACT* schemes where available.

Comparing 7.3a and c (from the previous section) with 7.4a and c shows that the non-mathematical records agree with our theoretical expectations in two ways. Firstly, Mercury's recorded periods of visibility are longer when its latitude at its appearance is higher. Secondly, the omitted phases occur when Mercury's period of visibility is at a minimum, as expected.

Comparing the non-mathematical records with the *ACT* values on each figure shows a good general agreement between the mathematical and the non-mathematical records of changes in longitude and date. Note in Figures 7.4a and c that, while the majority of the non-mathematical points fall very close to the *ACT* line, they are nearly all below it. In other words, the observed length of Mercury's period of visibility is virtually always smaller than the theoretical length from *ACT*. Equally, in Figure 7.4d the non-mathematical points fall close to the *ACT* line but nearly all *above* it, i.e. Mercury's period of invisibility is virtually always longer than the theoretical period from *ACT*. This result is logical if we assume that the *ACT* values are the ideal lengths of periods of visibility assuming perfect observing conditions. For the observational texts, weather effects can easily make observing conditions less than ideal, leading to Mercury's visibility period being shorter than expected (and the associated invisibility period being longer).

Figures 7.5a and c show that, similarly, the longitude changes across periods of visibility generally agree in *ACT* and in the non-mathematical texts. Yet there seem to be clear longitude regions where the dates from the non-mathematical texts result in a longitude difference which is almost always higher or lower than expected. At first glance this is rather surprising: Figures 7.4a and c showed that the number of *observed* days for which Mercury is visible is almost always lower than expected, so one might expect that a smaller number of days would always lead to a smaller change in longitude. However, this is not universally the case because Mercury's net longitude change during a phase of visibility or invisibility depends on how much of its motion is direct or retrograde.

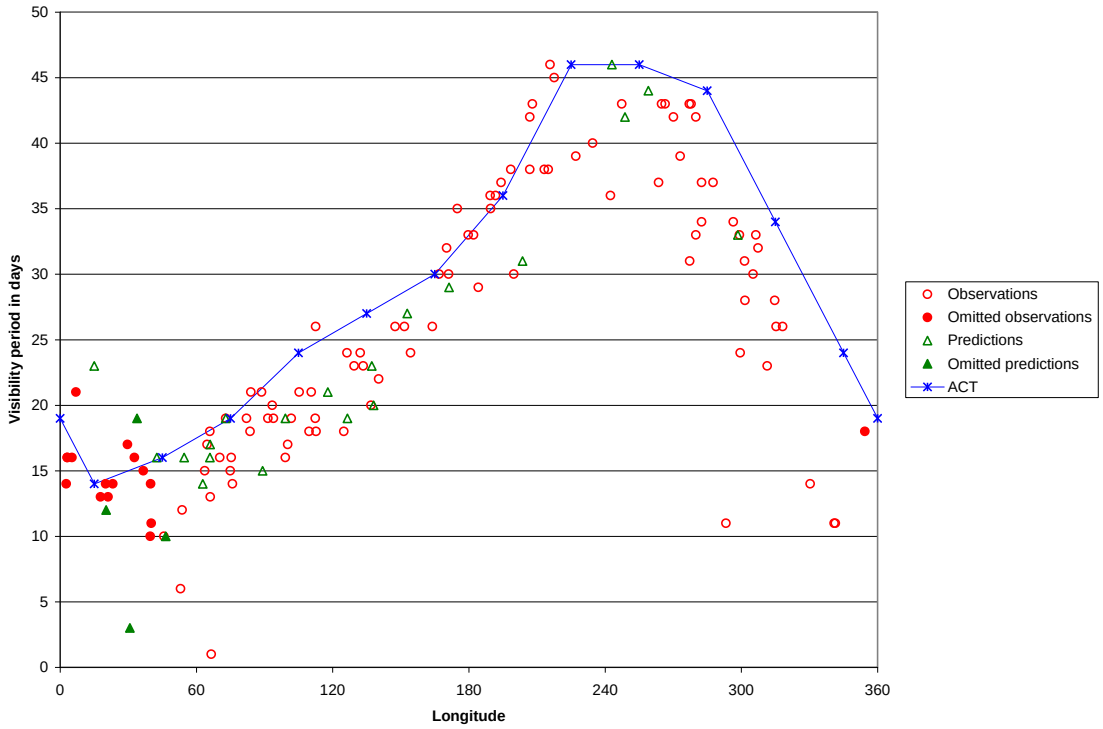

Figure 7.4a: Length of Mercury's eastern visibility in days, i.e. the number of days between a recorded first appearance and the following disappearance, plotted against Mercury's longitude at its appearance.

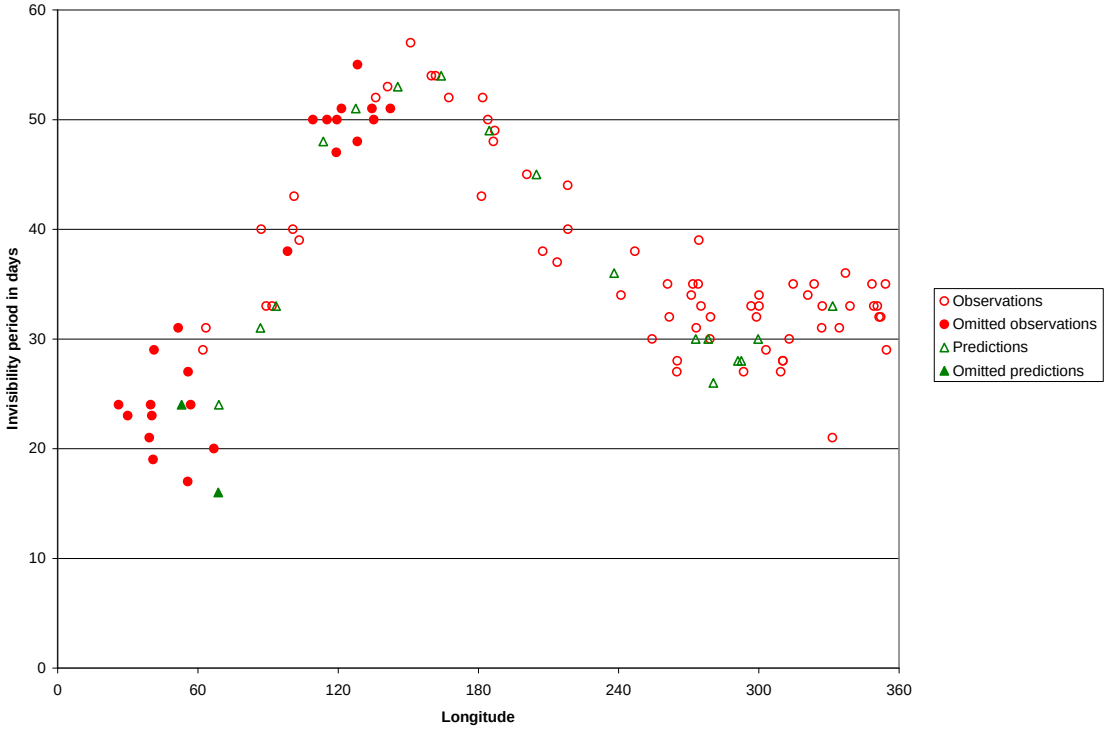

Figure 7.4b: Length of Mercury's invisibility in days, i.e. the number of days between an eastern disappearance and the following western appearance, plotted against Mercury's longitude at its disappearance.

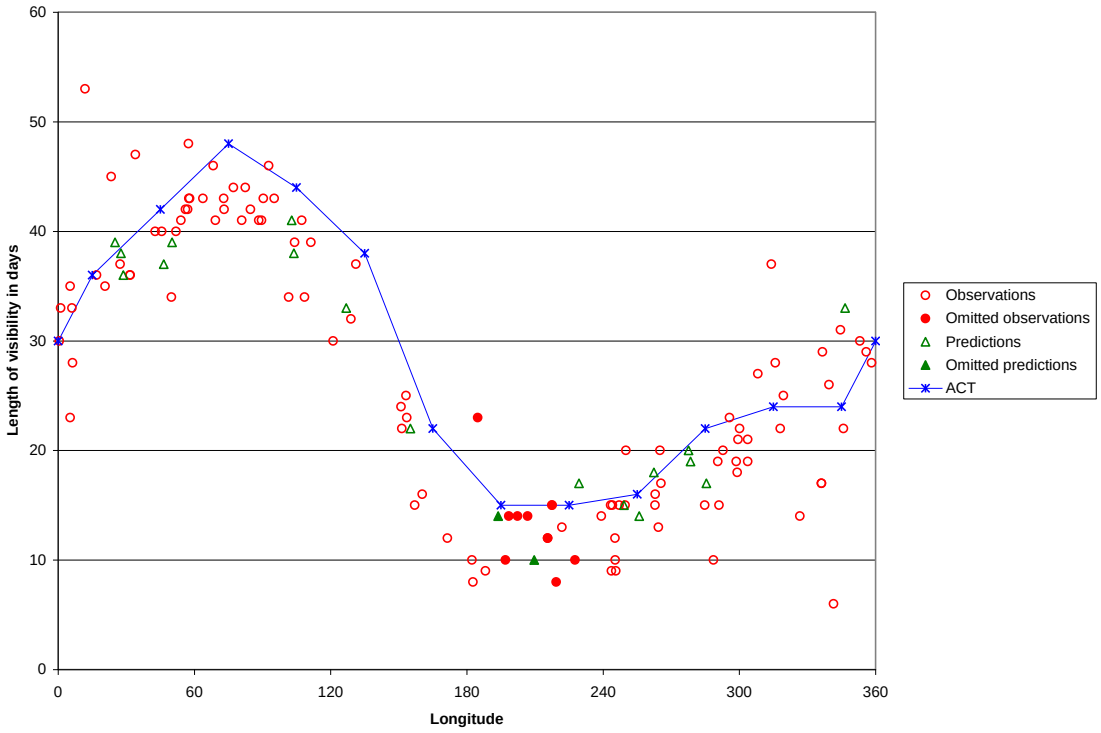

Figure 7.4c: Length of Mercury's western visibility in days, i.e. the number of days between a recorded first appearance and the following disappearance, plotted against Mercury's longitude at its appearance.

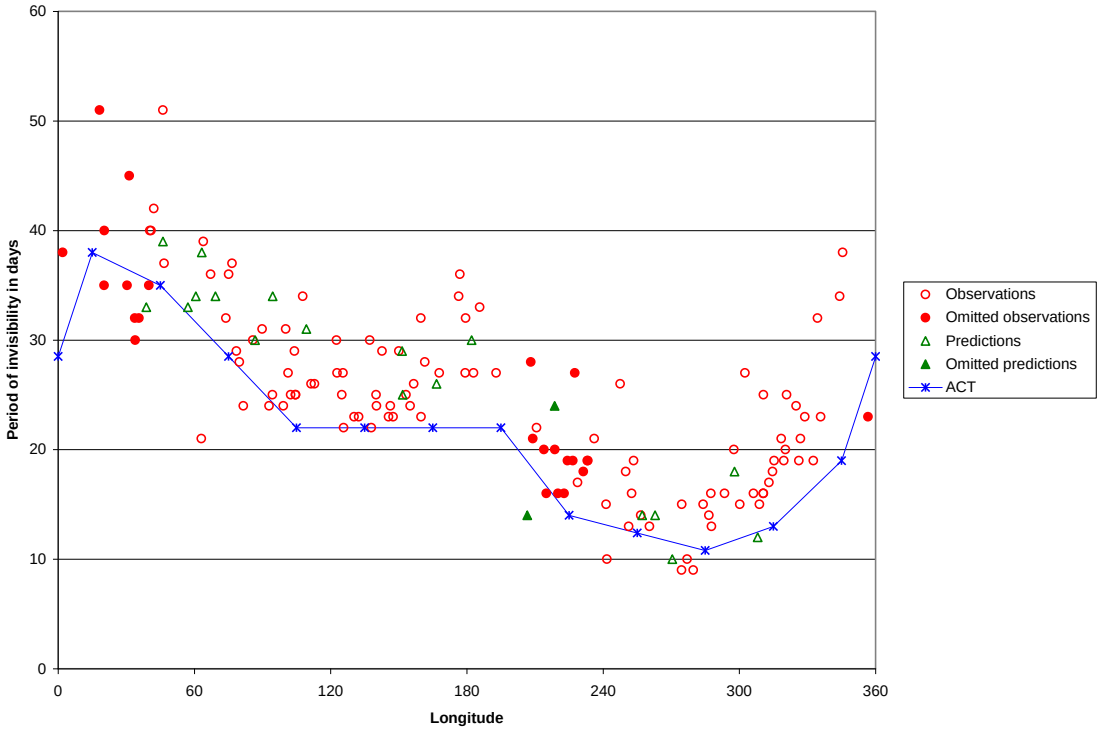

Figure 7.4d: Length of Mercury's invisibility in days, i.e. the number of days between a western disappearance and the following eastern appearance, plotted against Mercury's longitude at its disappearance.

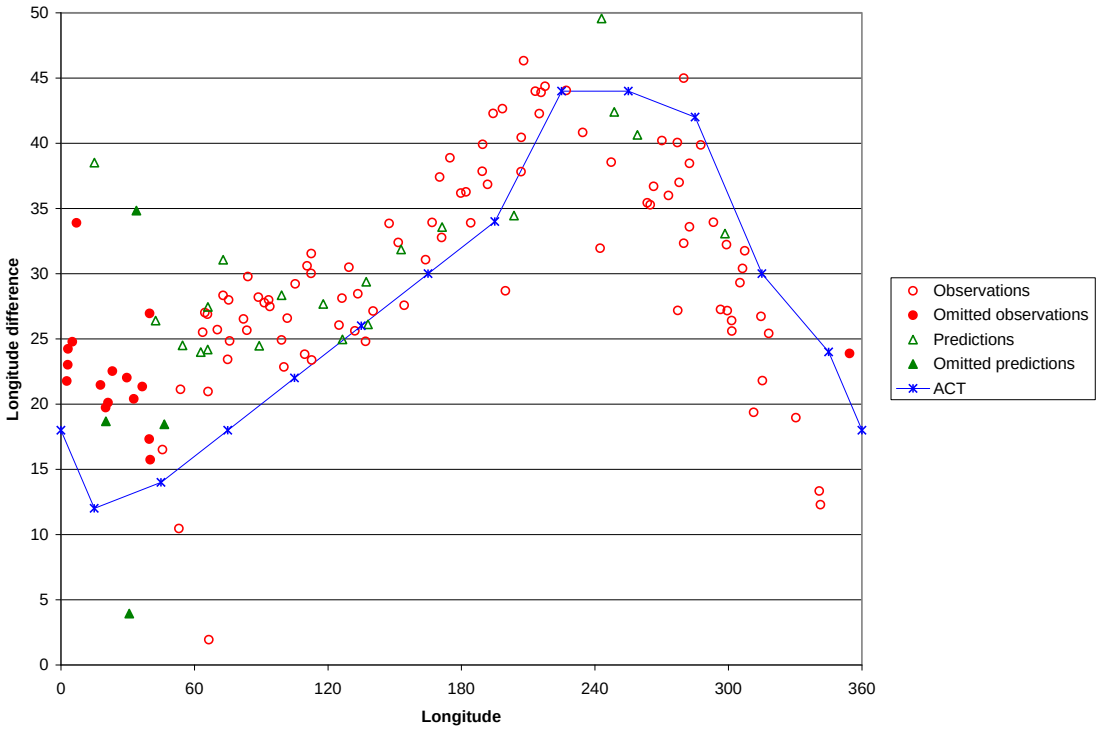

Figure 7.5a: The longitude change across Mercury's eastern period of visibility, i.e. the longitude difference between Mercury's appearance in the east and its subsequent disappearance, plotted against Mercury's longitude at its appearance.

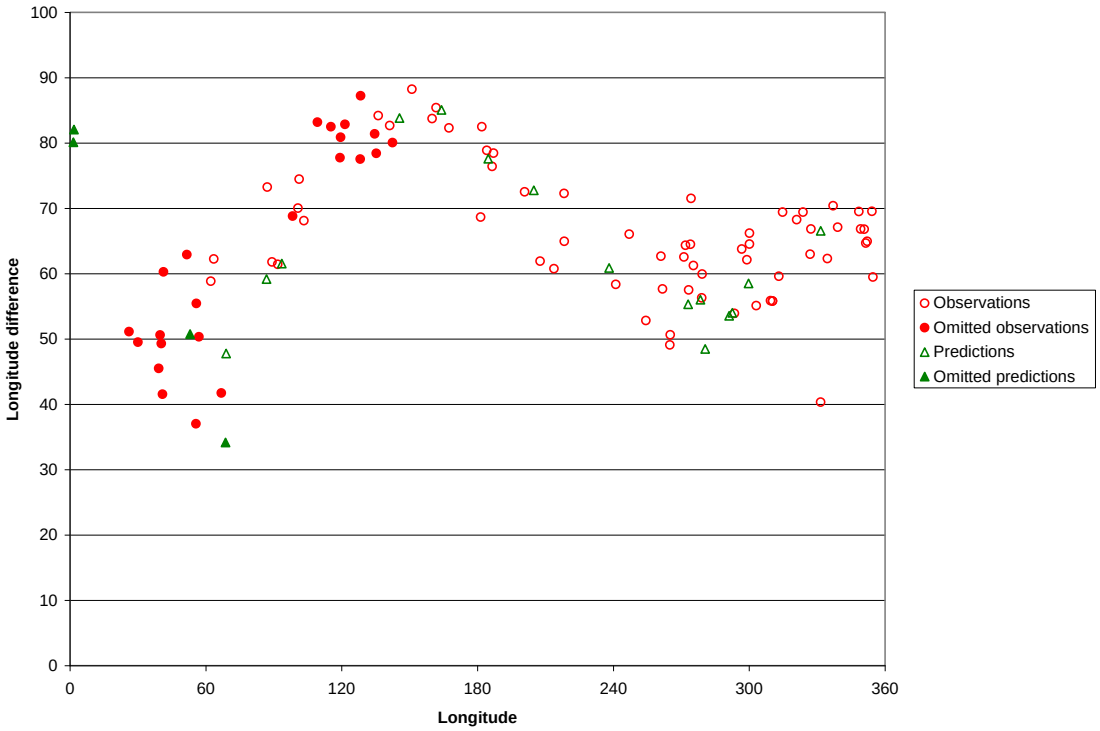

Figure 7.5b: The longitude change across Mercury's eastern period of invisibility, i.e. the longitude difference between Mercury's disappearance in the east and its subsequent appearance in the west, plotted against Mercury's longitude at its disappearance.

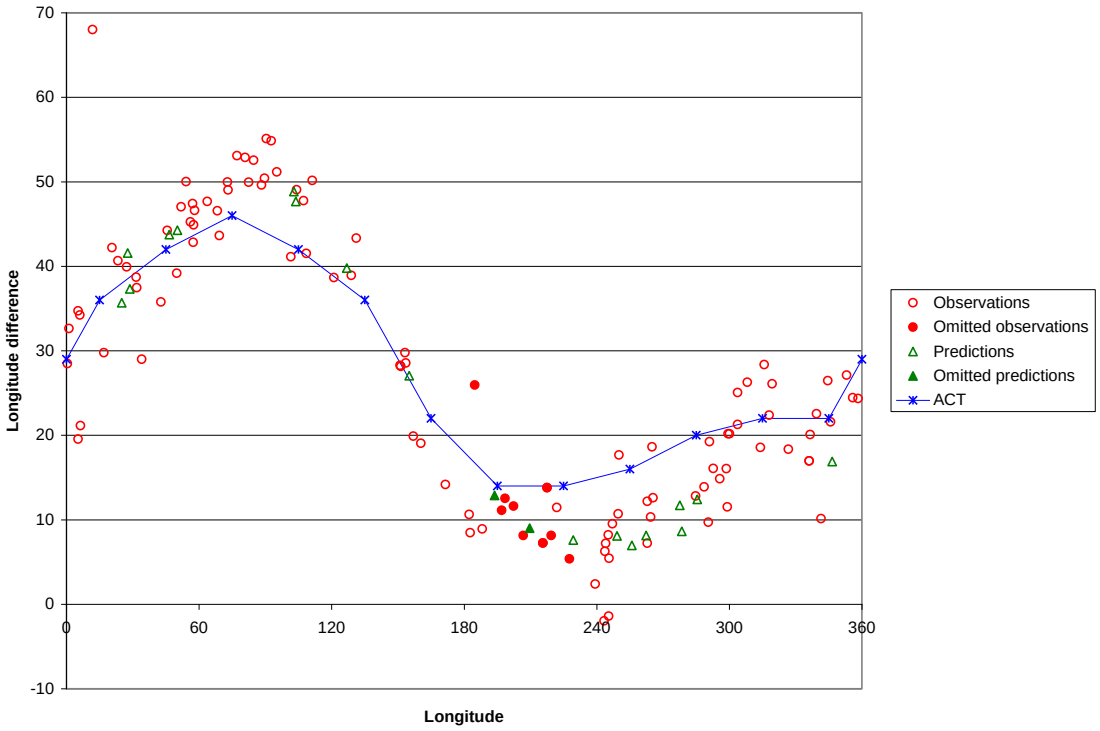

Figure 7.5c: The longitude change across Mercury's western period of visibility, i.e. the longitude difference between Mercury's appearance in the west and its subsequent disappearance, plotted against Mercury's longitude at its appearance.

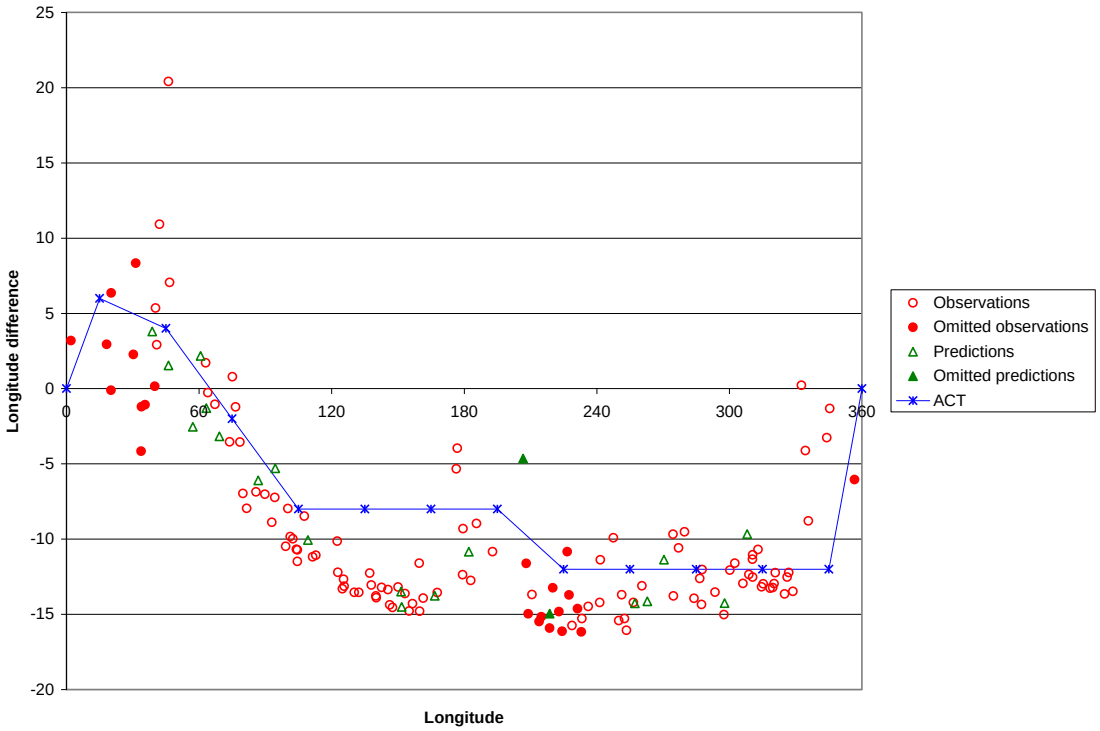

Figure 7.5d: The longitude change across Mercury's western period of invisibility, i.e. the longitude difference between Mercury's disappearance in the west and its subsequent appearance in the east, plotted against Mercury's longitude at its disappearance.

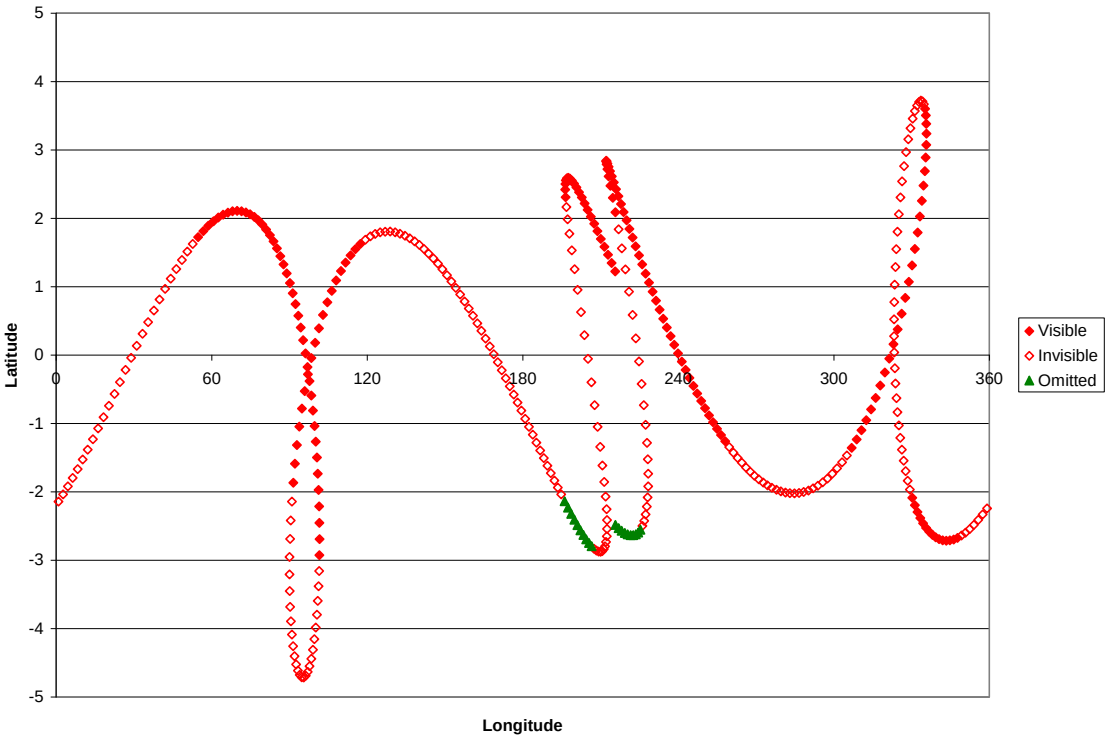

Figure 7.6: Mercury's longitude and latitude from October of -389 to November of -388, beginning and ending at a longitude of 215°. The regions where Mercury is visible or invisible from Babylon (according to *ADART* Vol. V No. 59) are marked.

Figure 7.6 illustrates Mercury's motion during a typical year, from October of -389 to November of -388, by plotting its longitude and latitude at midnight of each day according to JPL's "Horizons" ephemerides. During this time Mercury's longitude has moved through exactly 360°, so the figure chronologically begins and ends at 215° longitude. Conveniently, the text *ADART* Vol. V No. 59 has a completely preserved sequence of Mercury's Greek-letter phenomena for this period, spanning the 13 months from Month VII of Artaxerxes II year 15 to Month VII of Artaxerxes II year 16. The figure illustrates the regions where, according to the Babylonian dates, Mercury was visible, invisible, or in an omitted phase.

Notice that Mercury sometimes appears or disappears at a point where its longitude is changing fast, and sometimes at a point where its longitude is hardly changing at all from day-to-day. Therefore, Mercury appearing a couple of days later than expected will sometimes have very little impact on the net longitude difference, and sometimes have a large effect.

Notice also that Mercury's motion at its appearance can be either direct or retrograde. When Mercury becomes visible while moving retrograde, it is obvious that an observed first appearance a couple of days later than theoretically expected will lead to a *larger* net longitude difference between appearance and disappearance.

The comparison is clearer for Figure 7.5d, which shows Mercury's longitude change during its invisibility phase following a disappearance in the west. Mercury is always retrograde during at least some of this phase, so the longitude difference between these two phenomena is nearly always negative, as the figure demonstrates. Notice that the longitude differences from the non-mathematical texts are mostly larger in magnitude than the *ACT*

values deduced by Neugebauer. This agrees with the conclusion from Figure 7.4d, which showed that Mercury's observed period of invisibility was generally longer than expected by *ACT*. If Mercury's motion is generally retrograde at these times then a longer period of invisibility will lead to a larger negative change in longitude.

7.4 Conclusions

In this chapter I have outlined the fact that Mercury's visibility or invisibility on any particular date is a complex function, depending on the interaction of many related factors such as its latitude and elongation from the Sun, the ecliptic-horizon angle, and the observer's location and observing conditions. From this I have shown why some of Mercury's phases are impossible to see from Babylon, a phenomenon marked in the texts as "DIB" (passed by or omitted). Most of the researchers into Babylonian planetary theories do not discuss the mechanics of the omitted phases in any detail, despite the fact that the contributing factors of planetary latitude and elongation were known of as far back as Ptolemy's *Almagest*.

I have shown that the omitted phases in the non-mathematical texts occur at the expected points, where Mercury is at an extreme negative latitude and when the durations of its periods of visibility are lowest – in accordance with theoretical expectations, and with *ACT*'s ephemerides texts. Yet there is still the question of how observational texts such as the Astronomical Diaries could include dates of an event which is, by definition, not observable.

The evidence does not suggest that the omitted dates in the Diaries and other texts were taken directly from *ACT*, but I believe that the Babylonian astronomers had the tools to deduce dates and longitudes of the omitted phases using *ACT*-type methods from very early on in the Late Babylonian Period. That is, it would be simple to notice that Mercury did not appear for an entire eastern or western phase if one was employed to regularly watch out for it, and an interested observer could easily begin to deduce patterns for when this occurred by inspection of archived Diaries.

Chapter 8

Conclusions

8.1 The relationships between records in the non-mathematical texts

A major purpose of this work has been to understand the relationship between the records in the various types of non-mathematical astronomical text from the Late Babylonian Period. Chapter 2 compared records from the Astronomical Diaries and the Goal-Year Texts. The significantly high level of agreement between the records in these two texts confirms that it is extremely likely that the Goal-Year Texts' contents are excerpts from the Astronomical Diaries.

An important question, which had not previously been answered, was regarding the source of records in the non-mathematical predictive texts. In analysing this problem, I particularly looked at four potential solutions suggested by Sachs,[235] namely:

i) that the predictive records derive from the ephemerides in *ACT*,[236]
ii) that the predictive records derive from the observational records in the Goal-Year Texts,
iii) that both of the above sources together were used in the production of the non-mathematical predictions,
iv) that the Normal Star Almanacs used the Goal-Year Texts, and the Almanacs used the *ACT* ephemerides.

Chapter 2 considered the possibility that the predictions of planetary events could have been taken from the *ACT* ephemerides texts. However, a comparison of equivalent records in the various texts showed very clearly that this could not have been the case, because there was an extremely low level of agreement between dates of events in the ephemerides and the predictive texts. This means that solutions i) and iii) can be ruled out.

Chapter 5 compared records from the Normal Star Almanacs and the Almanacs. The small numbers of equivalent records consistently agree on the dates of events, strongly suggesting that the predictions the two types of text contain were derived from the same source. This rules out solution iv), or any other solution which would rely on the two types of text having their origins in different sources of records.

Therefore, we are left with solution ii) to analyse – that the predictive texts were compiled from the observational records in the Goal-Year Texts and, ultimately, derived from the Astronomical Diaries. Chapters 4, 5 and 6 considered this potential source of the non-mathematical predictions. In this theory, periods would be identified over which the planets' motion recurred. Excerpt texts such as the Goal-Year Texts, which consist of particular planets' observations for particular years, would then contain the observational "raw data" which could then be used to compile a predictive text for a specific year.

Chapter 4 examined planetary periods found in various Late Babylonian texts, and defined criteria against which we can compare the periods to determine how well they predict future events. Using theoretically calculated dates of planetary events to test the planetary periods, it was shown that the Goal-Year periods are virtually always those which best fit

[235] Sachs (1948), pp. 288-289.
[236] Neugebauer (1955).

the criteria. The "date corrections" to the planetary periods were deduced (necessary due to the fact that periods over which the planets' motion recur are rarely an exact number of Babylonian years).

It was also shown that, when using the Goal-Year periods to predict Normal Star passages, there would generally be no latitude difference between the planet- Normal Star distance at the time of a planetary passage, and the planet-Normal Star distance at the time of an equivalent planetary passage one Goal-Year period later. This is an important result because it would be extremely difficult to predict Normal Star passages effectively if the planetary periods did not demonstrate periodicity in the planet's latitude as well as its longitude.

Chapter 5 identified several potential issues with using Goal-Year periods for predictions. In this chapter the issue of date corrections was addressed. The predictions in the Normal Star Almanacs and the Almanacs were compared with Goal-Year Text records. By analysing equivalent records (i.e. records of an event occurring in both a Goal-Year Text and a predictive text covering the same year as the goal year), it was possible to deduce date differences between records of equivalent events. If the observational data in the Goal-Year Texts was in fact intended to be raw data for making predictions for the goal year, then these date differences should match the theoretically derived date corrections from the previous chapter. It was shown that the date differences generally agreed very well with the theoretically derived date corrections. In addition, equivalent records of Normal Star passages which were compared almost always contained identical measurements of the planet-star distance – again, as expected from the theoretical data in the previous chapter. These two results are very strong evidence that the predictions in the Normal Star Almanacs and Almanacs were made using the Goal-Year Text records.

Chapter 6 addressed another one of Chapter 5's potential issues with Goal-Year methods of prediction: the complications caused by the fact that Babylonian years are not a constant length. This implies that sometimes a "month shift" (changing the date of an observed record by ± 1 month to make a prediction) would be necessary when correcting the dates of records in the Goal-Year Text records to make predictions. This month shift is additional to, and entirely independent of, the date corrections deduced in the previous chapter. The dates of non-mathematical observational records (from the Diaries and the Goal-Year Texts) were compared with the dates of equivalent records from the predictive texts a Goal-Year period later. By analysing these dates it was shown that month differences between the observed and predicted events were always found at the points when they would be theoretically expected. This again lends strong support to the theory that the predictions in the Normal Star Almanacs and the Almanacs were derived from the Goal-Year Text records.

Further evidence to support to this relationship was found in Chapter 2: a comparison of records in the Astronomical Diaries of events which were not observed due to bad weather with records of equivalent events in the Normal Star Almanac or Almanac for the same year, shows that the dates of such events virtually always agree. This suggests that dates from the predictive texts were substituted into the Astronomical Diaries when bad weather prevented direct observation of an event.

In summary, analysis of records from the four major types of non-mathematical text: Astronomical Diary, Goal-Year Text, Normal Star Almanac and Almanac, suggests that they were closely related to each other. The evidence from the texts is consistent with the theory that the records were derived from each other as follows:

1. Observations of events -> written into Astronomical Diaries.

2. Astronomical Diary records for particular planets and years -> excerpted into Goal-Year Texts.

3. Goal-Year Text records -> rewritten chronologically, date corrections added or subtracted and month shifts applied as necessary, to make predictions for events of the goal year -> Almanacs and Normal Star Almanacs.

4. Almanacs and Normal Star Almanacs -> used to supply dates of events in Astronomical Diaries, when bad weather prevented observation.

8.2 Other contributions to knowledge of Late Babylonian astronomy

During the course of this study, a number of questions concerning various other aspects of Babylonian non-mathematical astronomy were also investigated and answered. In particular, analysing the data from the non-mathematical texts has allowed confirmation of results on several issues which had previously been mostly speculative. Additionally, the contents of considerable numbers of non-mathematical texts have become generally available (in the form of, for example, the *ADART* volumes) relatively recently and this has allowed the present study to verify other researchers' previous results by analysing a larger amount of data than was formerly available. These results will be outlined below.

Chapter 2 examined the contents of the Astronomical Diaries, showing that the planetary summaries at the end of each month were much more likely to include the "ideal" date of a planetary event rather than the observed date, where an ideal date was available. An analysis of parallel Astronomical Diaries covering the same time period showed that observers often disagree regarding measurements of time or distance when recording an astronomical event, and occasionally even disagree on the date of an event.

Chapter 3 examined the ways in which Normal Stars were used in the Normal Star Almanacs, as a direct comparison with Jones' work which analysed the usage of Normal Stars in observational texts.[237] This confirmed that the same Normal Stars were used in both types of text, and that the same patterns of "core" and "alternate" stars were found in each. However, as expected the Normal Star Almanacs do not include the full range of Normal Stars which are found in the observational texts. This is because many of the stars are only used in contexts outside the normal contents of a Normal Star Almanac; for example, exact positions of a planet's stationary point, or passages of the Moon by Normal Stars.

Also examined in Chapter 3 were the rare examples in the Almanacs and Normal Star Almanacs of predictions of stars' first and last visibilities (other than Sirius). Some of these stars have been identified, but others have not. By analysing the stars' rising and setting dates, and comparing these dates with Babylonian star lists such as those in *Enūma Anu Enlil,* MÚL.APIN, etc., the probable identity of each of the stars was suggested.

Chapter 3 also investigated planetary records involving zodiacal signs. Firstly, analysing the dates on which planets are recorded as reaching new zodiacal signs confirmed that the lengths of the zodiacal signs were always around 30° of longitude. Secondly, analysis of the

[237] Jones (2004)

planetary records concerning zodiacal signs demonstrated the important result that the Babylonian terminology SAG ("beginning") and TIL ("end") of a zodiacal sign was used to refer to about the first and last 5°, respectively, of the zodiacal sign.

Chapter 6 examined the occasional remarks found in the planetary sections of the Goal-Year Texts which did not relate to the planet's observations year. These fell into two general categories:

i) a record of a planetary event from the Month $XII_{(2)}$ immediately previous to the observations year or the Month I immediately following the observations year, or
ii) a remark that the observations year, or the year previous to the observations year, was intercalary.

It was shown that, as expected, records in category i) were those for which, once the necessary date correction had been applied, the equivalent event would fall within the goal year. Events in category ii) were initially assumed to be connected with keeping track of the required month shifts, but this was shown not to be the case. The remarks are not only found at points where a month shift would be necessary, and it was shown that remarks of this type occur much too infrequently to have been included for *every* intercalary month. Ultimately one is left to speculate that the infrequent nature of these remarks is a consequence of different Babylonian scribes employing different methods to keep track of the distribution of intercalary months.

Chapter 7 investigated the factors which affect Mercury's visibility, and showed how and why the interaction of these factors leads to the occurrence of "omitted" visibility phases. By analysing records of Mercury's appearance or disappearance from the non-mathematical texts, two important results were found:

i) Mercury's latitude at the time of its first appearance is strongly correlated with its longitude (and, by extension, the time of year). As expected, the omitted visibility phases occur when Mercury's latitude is at a minimum. The patterns of longitude-latitude dependence from the non-mathematical texts agree with the theoretically-derived patterns, and also with the procedure texts in *ACT*.
ii) The length of time for which Mercury remains visible or invisible is also strongly correlated with its longitude, and the time of year. As expected, the omitted visibility phases occur when the length of time Mercury is expected to remain visible is at a minimum, and the length of time Mercury is expected to remain invisible is at a maximum. These patterns again agree with the patterns derived from the procedure texts in *ACT*.

In conclusion, this study represents a significant advancement in our understanding of Late Babylonian non-mathematical astronomy. In particular, the interconnectedness of the various non-mathematical texts has been demonstrated. Analysis of the non-mathematical records has also enhanced many other aspects of our general awareness and appreciation of the Late Babylonian astronomers' methods.

Appendices

Appendix A: the contents of planetary summaries from the Astronomical Diaries

Diary year	Month	Contents of planetary summaries
-453	X	Summary includes observed date
-418	I	Summary includes observed date
-373	VII	Summary includes observed date
-366	IV	Ideal date given for event - summary includes observed date
-324	II	Summary includes observed date
-309	V	Summary includes event date - unclear whether ideal or observed
-308	V	Summary includes event date - unclear whether ideal or observed
-300	VII	Summary includes event date - unclear whether ideal or observed
-293	II	Ideal date given for event - summary includes observed date
-287	I	Summary includes observed date
-286	VII	Summary includes "around the" date - unclear whether ideal or observed
-284	VII	Summary includes event date - unclear whether ideal or observed
-284	VII	Ideal date given for event - summary includes "on the" ideal date
-284	VIII, XI	Summary includes observed date
-283	VII	Ideal date given for event - summary includes observed date
-273	XII	Ideal date given for event - summary includes "around the" ideal date
-266	II	Summary includes "around the" observed date
-264	VII	Summary includes "around the" date - unclear whether ideal or observed
-261	VII	Summary includes "around the" observed date
-261	IX	Ideal date given for event - summary includes observed date
-260	VI	Summary includes "around the" date - unclear whether ideal or observed
-257	IV	Summary includes "around the" date - unclear whether ideal or observed
-255	VI, VI_2	Summary includes "around the" date - unclear whether ideal or observed
-255	I	Summary includes "around the" observed date
-254	IX	Summary includes "around the" date - unclear whether ideal or observed
-253	VI	Summary includes "around the" observed date
-251	XII	Summary includes "around the" observed date
-251	VII	Summary includes observed date
-251	XII	Summary includes "around the" last seen date (not last visibility)
-249	IX	Ideal date given for event - summary includes "around the" ideal date
-249	IX, XII	Summary includes "around the" observed date
-247	VIII	Summary includes "around the" date - unclear whether ideal or observed
-246	I	Ideal date given for event - summary includes "around the" ideal date
-246	VI	Summary includes "around the" observed date
-241	II	Summary includes "around the" date - unclear whether ideal or observed
-237	IV	Ideal date given for event - summary includes "around the" ideal date
-237	V	Summary includes "around the" observed date
-234	VII	Summary includes "around the" observed date
-234	XI	Summary includes "around the" date - unclear whether ideal or observed
-232	VIII	Ideal date given for event - summary includes "around the" ideal date
-232	VIII, X	Summary includes "around the" observed date
-232	XI	Summary includes "around the" date - unclear whether ideal or observed
-230	I	Ideal date given for event - summary includes "around the" ideal date
-230	VI	Summary includes "around the" date - unclear whether ideal or observed
-226	II, III	Summary includes observed date
-225	III, IV	Summary includes "around the" observed date

Diary year	Month	Contents of planetary summaries
-225	IV	Summary includes observed date
-222	X	Summary includes "around the" date - unclear whether ideal or observed
-218	VII	Summary includes "around the" observed date
-218	XI	Summary includes "around the" date - unclear whether ideal or observed
-209	II	Ideal date given for event - summary includes "on the" ideal date
-209	III, IV	Summary includes observed date
-207	I, II	Summary includes event date - unclear whether ideal or observed
-204	I	Summary includes "around the" date - unclear whether ideal or observed
-203	VIII	Summary includes event date - unclear whether ideal or observed
-202	V, VII	Summary includes "around the" date - unclear whether ideal or observed
-198	IX	Summary includes "around the" observed date
-197	VII, VIII	Ideal date given for event - summary includes "around the" ideal date
-197	XII	Ideal date given for event - summary includes "around" a date which is neither the observed nor ideal date
-195	IX	Summary includes "around the" observed date
-194	III	Summary includes "around the" date - unclear whether ideal or observed
-193	VII	Summary includes "around the" date - unclear whether ideal or observed
-193	VIII	Summary includes observed and ideal date
-191	IV, VIII	Summary includes "around the" date - unclear whether ideal or observed
-190	II	Summary includes "around the" date - unclear whether ideal or observed
-190	III	Summary includes observed date
-189	II	Summary includes "around the" date - unclear whether ideal or observed
-187	XI	Summary includes "around the" date - unclear whether ideal or observed
-186	XII	Summary includes "around the" date - unclear whether ideal or observed
-186	X, XI	Summary includes observed and ideal date
-185	XII	Summary includes observed and ideal date
-183	II	Summary includes observed and ideal date
-182	I	Summary includes "around the" date - unclear whether ideal or observed
-180	XII	Summary includes event date - unclear whether ideal or observed
-178	XII	Summary includes "around the" observed date
-176	V	Summary includes "around the" date - unclear whether ideal or observed
-170	II	Ideal date given for event - summary includes "around the" ideal date
-170	V	Summary includes "around the" date - unclear whether ideal or observed
-168	V	Ideal date given for event - summary includes "around the" ideal date
-168	V, VI	Summary includes "around the" observed date
-168	VIII	Summary includes "around the" date - unclear whether ideal or observed
-165	V	Summary includes "around the" date - unclear whether ideal or observed
-164	VII	Ideal date given for event - summary includes "around the" ideal date
-164	XII	Summary includes "around the" date - unclear whether ideal or observed
-163	VIII, X, XII	Summary includes "around the" date - unclear whether ideal or observed
-162	V	Summary includes "around the" last seen date (not last visibility)
-161	I, V	Summary includes "around the" observed date
-161	I, II,	Summary includes "around the" date - unclear whether ideal or observed
-160	XI	Summary includes "around the" date - unclear whether ideal or observed
-158	V	Summary includes "around the" observed date
-156	I	Summary includes "around the" date - unclear whether ideal or observed
-155	IV	Summary includes "around the" observed date
-153	V	Summary includes "around the" observed date
-149	VII	Summary includes "around the" observed date
-146	IX	Summary includes "around the" date - unclear whether ideal or observed
-146	X	Ideal date given for event - summary includes "around the" ideal date
-146	X	Summary includes "around the" observed date
-144	VI	Summary includes "around the" date - unclear whether ideal or observed

Diary year	Month	Contents of planetary summaries
-144	VII	Ideal date given for event - summary includes "around the" ideal date
-143	V	Summary includes "around the" date - unclear whether ideal or observed
-143	VI	Ideal date given for event - summary includes "around the" ideal date
-141	VI, VI_2, XII	Summary includes "around the" date - unclear whether ideal or observed
-141	VII	Ideal date given for event - summary includes "around the" ideal date
-141	VI_2	Summary includes "around the" observed date
-140	I	Summary includes "around the" observed date
-140	IV	Summary includes observed date
-140	IX	Ideal date given for event - summary includes "around the" ideal date
-140	X	Summary includes "around the" date - unclear whether ideal or observed
-137	II, VIII, X	Summary includes "around the" observed date
-136	VII	Summary includes "around the" observed date
-136	X	Summary includes "around the" last seen date (not last visibility)
-133	XII	Summary includes "around the" date - unclear whether ideal or observed
-132	VII, XII	Summary includes observed date
-132	VII, X	Summary includes "around the" date - unclear whether ideal or observed
-126	VIII	Summary includes "around the" date - unclear whether ideal or observed
-125	I	Summary includes "around the" last seen date (not last visibility)
-125	V	Summary includes "around the" date - unclear whether ideal or observed
-124	II, IX, X	Summary includes "around the" date - unclear whether ideal or observed
-124	III	Summary includes "around the" observed date
-123	III	Ideal date given - Summary includes "around the" date - unclear whether ideal or observed
-122	II, XII	Summary includes "around the" date - unclear whether ideal or observed
-122	VI_2	Summary includes "around the" observed date
-120	V	Summary includes "around the" date - unclear whether ideal or observed
-119	I	Ideal date given for event - summary includes "around the" ideal date
-119	II	Summary includes "around the" date - unclear whether ideal or observed
-118	I, VII	Ideal date given for event - summary includes "around the" ideal date
-117	VIII	Summary includes "around the" date - unclear whether ideal or observed
-111	I	Ideal date given for event - summary includes "around the" ideal date
-111	I	Summary includes "around the" observed date
-110	V	Summary includes "around the" observed date
-110	V	Summary includes "around the" date - unclear whether ideal or observed
-109	VIII	Summary includes "around the" date - unclear whether ideal or observed
-108	IV	Summary includes "around the" last seen date (not last visibility)
-108	V	Ideal date given for event - summary includes "around the" ideal date
-108	VII	Summary includes "around the" date - unclear whether ideal or observed
-107	XI	Summary includes "around the" date - unclear whether ideal or observed
-105	I, V	Summary includes "around the" observed date
-105	III, VI	Summary includes observed date
-103	II	Summary includes "around the" date - unclear whether ideal or observed
-93	IV, V	Summary includes "around the" date - unclear whether ideal or observed
-90	X	Summary includes "around the" observed date
-90	XI	Summary includes "around the" date - unclear whether ideal or observed
-87	XII_2	Ideal date given for event - summary includes "around the" ideal date
-87	VI, XII	Summary includes "around the" date - unclear whether ideal or observed
-85	X	Ideal date given for event - summary includes "around the" ideal date
-77	III, V	Ideal date given for event - summary includes "around the" ideal date
-77	II, IV, XI	Summary includes "around the" observed date
-77	III, VII	Summary includes "around the" date - unclear whether ideal or observed

Appendix B: a comparison of overlapping records from the Diaries and the Goal-Year Texts

	Text No.		Observations year (SE)	
GYT	31	Obv.' 3-4	64	Around until the 19th, when Jupiter became stationary to the east, it became stationary behind the 4 rear ones of Sagittarius
Diary	-247 B	Rev. 4'		The 19th, Jupiter became stationary to the east, it [became stationary] behind the 4 (stars) of the breast of […]
GYT	49	Obv.' 3	85	[Jupiter,] while moving back to the east, was 4 ½ cubits below θ Leonis
Diary	-226	Rev.' 11		[21-23] first part Jupiter, while moving back to the east, was 4 cubits [below θ] Leonis
GYT	60	Obv.' 3	113	Around the 12th, Jupiter's last appearance in Capricorn
Diary	-198 C	Rev.' 2		Around the 12th, Jupiter's last appearance in Capricorn
GYT	63	Obv. 1	116	Around until the 26th, when Jupiter became stationary to the east, it became stationary 2 ½ cubits […]
Diary	-195	'Obv. 23'		Around the 26th, [when] Jupiter [became stationary to the east, it became stationary 2 ½ cubits …]
GYT	85	'Obv.' 2'	165	[… when it became station]ary in [… in became stationary] ½ cubit in front of μ Geminorum, 8 fin[gers …]
Diary	-146	Rev.' 3		[18-20th …] when Jupiter became stationary to the west, it became stationary 6 fingers in front of μ Geminorum, 8 fingers high to the north […]
GYT	20	Obv. 20	110	Night of the 2nd last part Venus was 2 cubits above α Scorpii
Diary	-201 B	Obv. 4		Night of the 3rd last part Venus was 3 cubits above α Scorpii
GYT	20	Obv. 20	110	Night of the 14th last part Venus was 2 cubits above θ Ophiuchi
Diary	-201 B	Rev. 8		Night of the 14th last part Venus was 2 cubits above θ Ophiuchi
GYT	22	Obv. 10'	114	[…] Venus' first appearance in the west in Sagittarius; […] (ideal) first on the 22nd
Diary	-197 B	Obv. 18		The 25th, Venus' first appearance in the east in Sagittarius; it was small, rising of Venus to sunrise: 9°; (ideal) first on [the 22nd …]

	Text No.		Observations year (SE)	
GYT	35	Obv. 11	132	The 30th, Venus' first appearance in the east in Pisces …… (ideal) first appearance on the 29th
Diary	-179 E	'Rev.' 12'		Around the 29th, Venus' [first appearance] in the east in Ar[ies …]
GYT	39	Obv. 18	136	Night of the 9th last part Venus was 1 cubit above θ Ophiuchi
Diary	-175 B	Obv.' 9		[8th-9th] last part Venus was 1 cubit above θ Ophiuchi
GYT	44	'Obv.' 11'	147	Night of the 21st last part Venus was 2/3 cubit below γ Virginis
Diary	-164 B	'Obv.' 9'		Night of the 21st last part Venus was [2/3 cubit] below γ Virginis
GYT	45	Obv.' 9	150	1 cubit? […] μ Geminorum
Diary	-161 A	'Obv,' 15'		[Night of the 2]5th first part Venus was 1 cubit above μ Geminorum
GYT	45	Obv.' 13	150	[…] 2 fingers above β Virginis, Venus [having passed] 2 fingers to the east
Diary	-161 A	'Obv. 4'		[… Ve]nus was 2 fingers above β Virginis, Venus having passed 2 fingers to the east
GYT	54	Obv.' 13-14	167	The 17th, Venus' [first appearance in the west in …] (ideal) first on the 15th?
Diary	-144	'Obv. 6'		[Around the 17th?] Venus' first appearance in the west in the end of Virgo; it was small, sunset to setting of Venus: 10° […]
GYT	54	Obv.' 14	167	Night of the 10th first part Venus was 3 cubits below β Capricorni
Diary	-144	Rev.' 28-29		Night of the 10th first part Venus was 3 cubits below β Cap[ricorni]
GYT	58	Obv.' 13	174	[Ni]ght of the 1st first part Venus was 4 fingers below α Virginis, Venus …
Diary	-137 A	'Rev.' 12'		The 1st, first part Venus was 5 fingers below α Virginis, Venus being 2 fingers back to the west
GYT	58	Obv.' 11	174	[…] 2/3 cubit [above] α Leonis, Venus having passed 4 fingers to the east
Diary	-137 B	'Rev.' 2'		[Night of the 7th first part Ven]us was 2/3 cubit above α Leonis.
GYT	58	Obv.' 12	174	[…] 4 ½ cubits [below] θ Leonis
Diary	-137 B	'Rev.' 11'		[Night of the 22nd first part Venus was] 4 ½ cubits [below θ Leonis]

	Text No.		Observations year (SE)	
GYT	63	Obv. 11	179	[…] Venus was 1 cubit 4 fingers below α Leonis
Diary	-132 B	Obv. 3		Night of the 3rd last part Venus was 1 cubit 4 fingers below α Leonis
GYT	63	Obv. 13	179	[…] Venus was ½ cubit [below γ] Virginis, Venus having passed 2 fingers to the east
Diary	-132 B	Rev. 3		Night of the 15th last part Venus was ½ cubit below γ Virginis, Venus having passed 4? fingers to the east
GYT	69	Obv. 16	186	Night of the 10[+x first part Venus was] 1? ½ cubits [below η Tau]ri
Diary	-125 B	'Rev.' 6'		[26-7th] first part Venus was 1 ½ cubits below η Tauri
GYT	70	'Obv.' 6'	188	[…] first part Venus was 3 [cubits] below β Librae
Diary	-123 B	'Flake' 7'		Night of the 16th first part Venus was 3 ½ cubits below β Librae …
GYT	71	'Obv. 9'	190	Night of the 15th first part Venus was 1 ½ cubits below γ Virginis
Diary	-121	'Obv. 10'		Night of the 13th …] Venus was 1 2/3 cubits [below γ] Virginis
GYT	73	Obv. 27'-28'	194	Night of the 25th first part Venus was 2? cubits? below η Tauri
Diary	-117 B	'Rev.' 16'		Night of the 26th first part Venus was 1 cubit below η Tauri
GYT	77	Obv. 5	199	Night of the 15th first part Venus […]; I did not see α Scorpii
Diary	-112	Obv.' 5		Night of the 15th first part Venus [was … above α Scorpii …]
GYT	82	Obv.' 9	217	Night of the 13th first part Venus was 3 cubits below β Geminorum
Diary	-94	'Flake' 11'		[13th...] first part Venus was 3 cubits below β Geminorum
GYT	5	Rev.' 15	35	The 23rd, Mercury's last appearance in the west in Aquarius
Diary	-276	'Rev.' 1'		The 26th, Mercury's [last appearance] in Aquar[ius …]

	Text No.		Observations year (SE)	
GYT	5	Rev.' 15	35	Around the 11th, first appearance in the east in Aquarius
Diary	-276	'Rev.' 4'		The 12th, Mercury's first appearance in the east in Aquarius
GYT	7	Obv. 16	45	The 14th, last appearance in the west in Sagittarius
Diary	-266 B	'Obv.' 16'		The 1st, Mercury's last appearance in the west in Sagittarius
GYT	15	Obv. 20	60	The 11th, Mercury's first appearance in the west … omitted
Diary	-251	Obv. 3		The 11th, Mercury's first appearance in the west, omitted
GYT	15	Obv. 20	60	The 26th, Mercury's […]
Diary	-251	Obv. 6		Around the 26th, Mercury's last appearance in the west, omitted
GYT	28	'Obv.' 2'	85	The 13th, Mercury's […] in the east
Diary	-226 A	'Obv. 19'		The 13th, Mercury's first appearance in the east … omitted
GYT	34	'Obv.' 6'	93	Around the 25th, Mercury's last appearance in the west … omitted
Diary	-218	'Obv.' 2'		The 25th, Mercury's last appearance in the west … omitted
GYT	50	'Obv. 8'	122	The 8th, Mercury's last appearance in the west in Gemini; I did not watch
Diary	-189 A	'Obv.' 11'		Around the 8th, Mercury's last appearance in the west in Gemini; I did not watch
GYT	53	'Obv.' 21'	125	Around the 1st, Mercury's last appearance in the west in the end of Pisces; I did not watch
Diary	-186 A	'Rev. 5'		[… the 1st, Mercu]ry's last appearance in the west in the end of Pisces; I did not watch
GYT	53	Obv. 20'-21'	125	The 14th, Mercury's [first appearance] in the west in Pisces, [it stood] 2 ½ cubits behind Venus to the east; [it was bri]ght and high, sunset to setting of Mercury: 16°; (ideal) first on the 12th
Diary	-186 C	Obv. 15		The 14th, Mercury's first appearance in the west in [Virgo], it stood 2 ½ cubits behind Venus to the west(sic); it was bright and high, sunset to setting of Mercury: 16°; (ideal) first on the 12th

	Text No.		Observations year (SE)	
GYT	62	Obv.' 14	140	[The 1]6th, Mercury's last appearance in the east in Aries, I did not watch
Diary	-171 A	'Rev.' 6'		The 16th, Mercury's last appearance in the east in Aries
GYT	62	Obv.' 17	140	The 17th, Mercury's last appearance in the east in the beginning of Leo
Diary	-171 B	Obv.' 3		The 18th, Mercury's last appearance in the east in the beginning of Leo
GYT	69	Obv. 21	148	Night of the 2nd first part Mercury was 1 ½ cubits below β Tauri
Diary	-163 A	Obv.' 2		The 1st, first part Mercury was 1 ½ [cubits] below β Tauri
GYT	69	Obv. 22	148	Night of the 9th first part Mercury was 1 cubit 4 fingers above η Geminorum
Diary	-163 A	Obv.' 11		Night of the 9th first part Me[rcury was … above η Geminorum]
GYT	69	Obv. 22-23	148	Night of the 11th first part [Mercury was] 1 cubit 4 fingers above μ Geminorum
Diary	-163 A	Obv.' 14		Night of the 11th first part Mercury was 1 2/3 cubits above μ Geminorum
GYT	69	Obv. 23	148	Night of the 15th first part Mercury was 4 ½ cubits [above γ] Geminorum
Diary	-163 A	Obv.' 18		Night of the 15th first part [Mercury was] 4 ½ cubits [above γ Geminorum]
GYT	69	Obv. 31-32	148	The 17th, Mercury's last appearance [in the ea]st [in] Pisces: from the 14th in the end of Aquarius, when I watched I did not see it
Diary	-163 B	'Rev. 10'		Around the 14th, Mercury's [last appearance in the east in Aquarius …]
GYT	69	Obv. 28-29	148	[Mercury's last appearance in the west] in Aquarius: from the 20th when I watched I did not see it
Diary	-163 C_2	'Obv. 15'		Around the 20th, Mercury's last appearance in the west in Aquarius
GYT	69	Obv. 29-30	148	The 10th, Mercury's first appearance in the east in Capricorn, 3 cubits behind β Capricorni, 1 ½[2] cubits … (ideal) first appearance on the 8th
Diary	-163 C_2	Rev.' 4		The 10th, Mercury's [first appearance] in the east in Capricorn, 3 cubits behind [β Capricorni…]

	Text No.		Observations year (SE)	
GYT	73	Obv. 32'-33'	155	[Night of the 1]9th first part Mercury was 1 ½ cubits above ζ Tauri
Diary	-156 A	'Obv.' 8'		Night of the 19th first part Mercury was 1 ½ cubits above ζ Tauri
GYT	73	Obv. 33'	155	Night of the 10[+xth first part Mercury was] 1[?] cubit 4 fingers [above η Geminorum]
Diary	-156 A	'Obv.' 12'		[…] first part Mercury was 1 cubit 4 fingers above η Geminorum
GYT	73	Rev. 7-8	156	The 24th, Mercury's [first appearance] in the west in Leo, 4 fingers below [Venus, being 2 fingers back to the west;] it was small, sunset to setting of Mercury: 15°
Diary	-155A	Obv. 14-15		The 24th, Mercury's [first appearance] in the west in Leo, 4 fingers below Venus, 2 fingers […] it was small, sunset to setting of Mercury: 15°
GYT	82	Obv.' 17-18	179	The 8th, Mercury's first appearance in the west in Gemini, it was bright and high, sunset to setting of Mercury: 15°30', (ideal) first on the 6th.
Diary	-132 A	'Obv.' 13'		[8-9th …] Mercury's first appearance in the west in Gemini, it was bright, sunset to setting of Mercury: 15°30' [(ideal) first] on the 5th […]
GYT	82	Obv.' 20	179	The 2nd, Mercury's first appearance in the west … omitted
Diary	-132 B	Obv. 31		The 2nd, Mercury's first appearance in the west … omitted
GYT	82	Obv.' 20-21	179	The 14th[?], [Mercury's last appearance] in the west … omitted
Diary	-132 B	Rev. 2		The 14th, Mer[cury's last appearance in the west …] omitted
GYT	82	Obv. 21-22	179	[The xth], Mercury's first appearance in the east in the beginning of Scorpius, 3 cubits behind β Librae, 2 ½ cubits low to the south; it was bright, rising of Mercury to sunrise: 16°; (ideal) first on [the xth] of Month VII
Diary	-132 B	Rev. 17		Around the 29th, Mercury's [first appearance in] the east in Scorpius
GYT	86	Obv. 21	190	The 19th, Mercury's first appearance in the west in Cancer; sunset to setting of Mercury: 15°; (ideal) first on the 17th
Diary	-121	'Obv. 4'		Around the 17th, Mercury's [first appearance] in the west in Cancer

	Text No.		Observations year (SE)	
GYT	12	'Obv. 4'	38	Until the 4th Saturn became stationary to the west, [it became stationary] in Aqua[rius]
Diary	-273 B	Obv.' 1-2		The 4th, [Saturn became stationary in Aquarius, I did not watch]
GYT	12	'Obv. 5'	38	[…the 2]1st, Saturn's first appearance in Pisces; it was bright and high; rising of Saturn to sunrise: 18°, (ideal) first on the 19
Diary	-273 B	'Rev. 23'		The 2[1st, Saturn's] first appearance in Pisces; it was bright and high; rising of Saturn to sunrise: 17°, (ideal) first on the 19
GYT	18	'Obv. 5'	48	Around the 18th, Saturn's acronychal rising
Diary	-263	'Obv.' 14'		The 18th, Saturn's acrony[chal rising]
GYT	50	'Obv. 17'	109	[… Sat]urn's first appearance in Leo, 2 2/3 cubits behind α Leonis to the east … (ideal) first on the 11th
Diary	-202 A	'Rev.' 8'		Around the 11th, Saturn's first appearance in Leo
GYT	53	'Obv.' 22'	112	Until the 28th[?], when Saturn became stationary to the west, [it became stationary] 2 ½ cubits behind β Vir[ginis]
Diary	-199 A	'Obv.' 3'		Around the 1st, when Saturn [became stationary to the west, it became stationary nn cubits] [behind β Virginis]
GYT	61	'Obv. 28'	126	The 30th, Saturn's [first appearance] in the beginning of Pisces, ½[?] cubit in front[?] of…
Diary	-185 B	'Obv.' 8'-9'		Around the 30th, Saturn's first appearance ½ cubit below Mars, it stood 2 cubits [in front of Jupiter to] the west, 3 ½ cubits behind Mercury to the east …
		'Obv.' 6'-7'		alt: The 22nd, Saturn's first appearance in the beginning of Pisces [2 cubits in] front of Jupiter to the west … (ideal) first on 21st
GYT	74	Obv.' 30	143	Around[?] the 27th, Saturn's [first appearance in …]
Diary	-168 B	'Obv.' 9'		The 27th, Saturn's [first appearance] in Libra
GYT	77	Obv. 23	148	[… Saturn's last appearance] in Scorpio: from the 11th, when I watched I did not see it
Diary	-163 C_1	'Obv.' 8'		Around the 11th, Saturn's last appearance in the end of Scorpio
GYT	86	Obv. 28	177	The 4th, Saturn's last appearance in Scorpio, from the 2nd when I watched I did not see it
Diary	-134 B	Obv.' 19		The 4th, setting of Saturn in Scorpio, from the 1st when I watched I did not see it

	Text No.		Observations year (SE)	
GYT	5	Rev.' 25	34	[…] Mars was 2 cubits below α Scorpii
Diary	-277 C	Obv. 3		Night of the 11th first part Mars was 2 ½ cubits above α Scorpii
GYT	12	Rev.' 6	50	Night of the 28th last part Mars was […] above [ϱ Leonis]
Diary	-261 C	Obv.' 8		[Night of the 28th last part Mars] was 10 fingers [above] ϱ Leonis
GYT	18	Rev.' 1	28	The 23rd, Mars' first appearance in Libra; rising of Mars to sunrise: 18°; (ideal) first on the 19$^{?}$
Diary	-283 A	Obv. 5		The 30th, Mars' first appearance in Libra; rising of Mars to sunrise: 19°; (ideal) first on the 21
GYT	20	Obv. 34-35	71	[… Mars …] 4 fingers [… α Librae]
Diary	-240	'Obv. 12'		Night of the 11th last part Mars was 4 fingers above α Librae
GYT	27	Obv. 33	50	Until the 23rd, when Mars [became stationary] to the west […]
Diary	-261 B	'Rev.' 5'		[… Around the 23rd, when Mars became stationary to the west, it became stationary … behind ϱ Le]onis, 1 cubit behind Sa[turn …]
GYT	27	Rev. 1-2	82	[… Mars, while] moving [back to the west,] was 4 cubits below θ Leonis
Diary	-229 B	'Rev.' 6'		[Night of the 18th first part Mars was] 4 cubits […θ] Leonis
GYT	90	'Rev.' 8'	199	[Night] of the 25th last part Mars was […] above δ Cap[ricorni]
Diary	-112	'Rev. 11'		[Ni]ght of the 25th last part Mars was […] above δ Capri[corni]

Appendix C: a comparison of Greek-letter phenomena dates from the ACT ephemerides and the non-mathematical predictive texts

Planet	Scheme	
Mercury	A2	no comparisons remain

Mercury	A1						Zodiacal sign						
ACT		Duplicates	Year	Month	Day	Observation	ACT	Prediction	Predictive text		Month	Day	Dates agree[?]
300	Obv. 36		129	III	22	first appearance	Gemini	Gemini	LBAT 1123	Obv. 6	III	24	No
300	Obv. 36		129	IV	11	last appearance	[…]	Gemini	LBAT 1123	Obv. 7	IV	9	No
300	Rev. 4		133	V	9	last appearance	[…]	Leo	MLC 1885	Obv. 9	V	10	No
300	Rev. 5		133	VIII	[3]	first appearance	Scorpio	Libra	MLC 1885	Rev. 5	VII	29	No
300	Rev. 5	301 Obv. 2	133	IX	15	last appearance	Sagittarius	Sagittarius	MLC 1885	Rev. 9	IX	13	No
301	Obv. 1		133	III	23	last appearance	Cancer	Cancer	MLC 1885	Obv. 2	III	23	Yes
301	Obv. 1		133	V	6	last appearance	Leo	Leo	MLC 1885	Obv. 9	V	10	No
301	Obv. 2		133	VI	29	first appearance	Libra	omitted	MLC 1885	Rev. 1	VII	2	No
301	Obv. 2		133	VII	14	last appearance	Scorpio	omitted	MLC 1885	Rev. 3	VII	14	Yes
301	Obv. 2		133	VII	29	first appearance	Scorpio	Libra	MLC 1885	Rev. 5	VII	29	Yes
301	Obv. 8		147	VI	14	first appearance	Libra	Libra	MLC 2915	Obv. 11	VII	22	No
301	Obv. 8		147	VIII	20	last appearance	Scorpio	Sagittarius	MLC 2915	Obv. 15	IX	10	No
301	Obv. 9		147	X	9	first appearance	Capricorn	Aquarius	MLC 2915	Rev. 1	X	8	No
301	Obv. 9		147	XI	1	last appearance	Aquarius	Aquarius	MLC 2915	Rev. 3	XI	1	Yes
301	Obv. 9		147	XI	9	first appearance	Aquarius	Aquarius	MLC 2915	Rev. 3-4	XI	15	No
301	Obv. 9		147	XII	13	last appearance	Pisces	Pisces	MLC 2915	Rev. 6	XII	19	No
301	Obv. 16		150	I	17	last appearance	Taurus	Taurus	LBAT *1030	Obv. 3-4	I	19[?]	No
301	Obv. 16		150	II	10	first appearance	Taurus	Taurus	LBAT *1030	Obv. 8	II	19	No
301	Obv. 17		150	V	10	last appearance	Virgo	Virgo	LBAT *1030	Obv. 19-20	V	14	No
301	Obv. 17		150	V	25	first appearance	Leo	Virgo	LBAT *1030	Obv. 24	VI	8	No
301	Obv. 17		150	VI	22	last appearance	Virgo	Virgo	LBAT *1030	Rev. 1	VII	5 or 4	No
302	Obv. 17		172	V	1	first appearance	Cancer	Cancer	LBAT 1038	Obv. 20	V	2	No

302	Obv. 18	172	VIII	21	first appearance	Scorpio	Sagittarius	LBAT 1038	Rev. 9	X	1	No
302	Obv. 19	172	XI	7	first appearance	Aquarius	[…]	LBAT 1038	Rev. 13	XI	5	No
302	Rev. -2	178	II	8	last appearance	Aries	omitted	LBAT 1134	Obv. 2	II	21	No
302	Rev. -1	178	V	16	first appearance	Leo	Leo	LBAT 1134	Obv. 9	V	20	No
302	Rev. -1	178	VI	12	last appearance	Leo	Leo	LBAT 1134	Obv. 12	VI	12	Yes
302	Rev. 0	178	VIII	4	first appearance	Scorpio	Scorpio	LBAT 1134	Rev. 1	VIII	6	No
302	Rev. 1	178	XI	24	first appearance	Pisces	Pisces	LBAT 1134	Rev. 10	XI	21	No
302	Rev. 4	179	X	18	first appearance	Aquarius	Aquarius	LBAT 1136	Rev. 6	X	16	No
302	Rev. 4	179	XI	10	last appearance	Pisces	Pisces	LBAT 1135	Rev. 2	XI	11	No
302	Rev. 4	179	XII	30	last appearance	Pisces	[…]	LBAT 1135	Rev. 6	XII	29	No
302	Rev. 14	183	I	23	first appearance	Taurus	omitted	LBAT 1137-8	Obv. 7	III	3	No
302	Rev. 14	183	III	7	last appearance	Taurus	omitted	LBAT 1137-8	Obv. 8	III	13	No
302	Rev. 15	183	V	14	last appearance	Virgo	Gemini	LBAT 1137-8	Obv. 13	V	20	No
302	Rev. 16	183	VIII	25	first appearance	Sagittarius	Sagittarius	LBAT 1137-8	Rev. 4	VIII	29	No
302	Rev. 16	183	IX	11	last appearance	Sagittarius	[…]	LBAT 1137-8	Rev. 5	IX	14	No
302	Rev. 16	183	IX	27	first appearance	Sagittarius	[…]	LBAT 1137-8	Rev. 6	IX	27	Yes
302	Rev. 16	183	XI	4	last appearance	Capricorn	Capricorn	LBAT 1137-8	Rev. 9	XI	10	No
302	Rev. 17	183	XII	14	first appearance	Pisces	Pisces	LBAT 1137-8	Rev. 11	XII	10	No
302	Rev. 19	184	X	8	last appearance	Capricorn	Capricorn	LBAT 1047	Obv. 15	X?	5	No
302	Rev. 20	184	XI	10	first appearance	Pisces	Pisces	LBAT 1047	Obv. 18	XI?	7	No
302	Rev. 20	184	XII	2	last appearance	Aries	Aries	LBAT 1048	Line 25	XII	3	No
302	Rev. 30	188	I	7	first appearance	Taurus	Taurus	LBAT 1051	Obv. 1	I	7	Yes
302	Rev. 30	188	II	16	last appearance	Gemini	Gemini	LBAT 1051	Obv. 8	II	13	No
302	Rev. 30	188	III	16	first appearance	Gemini	Gemini	LBAT 1051	Obv. 15	III	17	No
302	Rev. 30	188	IV	5	last appearance	Gemini	[…]	LBAT 1051	Obv. 19	IV	5	Yes
302	Rev. 31	188	VI	30	first appearance	Virgo	Virgo	LBAT 1052	Obv. 9-10	VI	29	No
302	Rev. 31	188	VIII	2	last appearance	Libra	Libra	LBAT 1052	Rev. 5	VII	30	No
302	Rev. 32	188	X	6	last appearance	Capricorn	Aquarius	LBAT 1051	Rev. 10	X	8	No
302	Rev. 32	188	X	19	first appearance	Capricorn	Capricorn	LBAT 1051	Rev. 11	X	20	No
302	Rev. 32	188	XII	4	last appearance	Aquarius	Aquarius	LBAT 1051	Rev. 19	XI	28	No
302	Rev. 33	189	II	9	last appearance	Taurus	Taurus	LBAT **1055	Obv. 8	II	4	No

302	Rev. 33		189	III	12	first appearance	Taurus	Taurus	LBAT **1055	Obv. 14-15	III	12	Yes
302	Rev. 33		189	III	29	last appearance	Gemini	Gemini	LBAT **1055	Obv. 17	III	28	No
302	Rev. 34		189	IV	24	first appearance	Leo	Leo	LBAT **1055	Obv. 23	IV	26	No
302	Rev. 34		189	VI	24	first appearance	Virgo	Virgo	LBAT **1055	Obv. 37-38	VI	25	No
302	Rev. 34		189	VI_2	23	last appearance	Libra	Libra	LBAT **1055	Rev. 43	VI_2	23	Yes

Venus	A0					Zodiacal sign						
ACT no			Year	Month	Day	Observation	ACT	Prediction	NSA/Alm no		Month	Day	Dates agree[2]
400	Obv. 1		111	V	27	first appearance	Libra	Libra	LBAT 1020	Obv. 13	VI[2]	12	No
400	Rev. 0		129	I	12	first appearance	Taurus	Taurus	LBAT 1123	Obv. 2	I	21	No

Venus	A1					Zodiacal sign						
ACT no			Year	Month	Day	Observation	ACT	Prediction	NSA/Alm no		Month	Day	Dates agree[2]
410	Line 1		236	II	6	first appearance	Gemini	Gemini	LBAT 1174	Obv. 3	II	6	Yes
410	Line 1		236	X	18	last appearance	Aquarius	Aquarius	LBAT 1174	Rev. 7	XI	6	No
411	Line 2		248	I	24	first appearance	Aries	[…]	LBAT 1183	Obv. 1	I	16	No

Venus	A2					Zodiacal sign						
ACT no			Year	Month	Day	Observation	ACT	Prediction	NSA/Alm no		Month	Day	Dates agree[2]
420	Obv. 6	421a Obv. 3	188	XI	27	last appearance	Pisces	Pisces	LBAT 1051	Rev. 20	XI	29	No
420	Obv. 6	421a Obv. 3	188	XII	1	first appearance	Pisces	Pisces	LBAT 1051	Rev. 21	XII	1	Yes
420	Obv. 12	421a Obv. 9	198	VI	6	last appearance	Libra	[…]	LBAT 1148-9	Obv. 5	VI	2	No
420	Obv. 12	421a Obv. 11	201	IX	5	last appearance	Sagittarius	Sagittarius	LBAT **1059	Line 48	IX	3	No
420	Obv. 12	421a Obv. 11	201	IX	6	first appearance	Sagittarius	Sagittarius	LBAT **1059	Line 48	IX	5	No
420	Obv. 12	421a Obv. 11	201	IX	6	first appearance	Sagittarius	[…]	LBAT 1151	Rev. 3	IX	6	Yes
420	Rev. 2		233	VIII	20	first appearance	Sagittarius	Sagittarius	LBAT 1160	Rev. 2	VIII	20	Yes
420	Rev. 4		236	XI	3	last appearance	Aquarius	Aquarius	LBAT 1169-74	Rev. 4	XI	6	No
420	Rev. 4		236	XI	7	first appearance	Aquarius	Aquarius	LBAT 1169-74	Rev. 4	XI	8	No

Mars	A						Zodiacal sign					
ACT no			Year	Month	Day	Observation	ACT	Prediction	NSA/Alm no		Month	Day	Dates agree?
500	Obv. 18		127	IX	26	acronychal rising			BM 32888	Rev. 4	IX	20	No
500	Obv. 19		129	XI	20	acronychal rising			LBAT 1123	Rev. 1	XI	14	No
501	Obv. 29	501b Obv. 5	183	II	26	station	Aquarius	Capricorn	LBAT 1137-8	Obv. 5	II	20	No
501	Rev. 2		189	VII	17	station	Cancer	Cancer	LBAT **1055	Rev. 45	VII	11	No

Jupiter	A						Zodiacal sign					
ACT no			Year	Month	Day	Observation	ACT	Prediction	NSA/Alm no		Month	Day	Dates agree?
600	Obv. 4		116	IV	22	station	Aries	Aries	1021	Obv. 3	IV	26	No
600	Obv. 16		129	VI	28	station	Gemini	Gemini	1123	Obv. 12	VII	1	No
600	Obv. 20		133	X	20	[station]	Libra	Libra	MLC 1885	Rev. 13	X	24	No
600	Rev. 6		156	X	12	station	Virgo	Virgo	1032	Rev. 7	X	10	No
601	Obv. 14	602 Obv. 18	150	VII	10	station	Aquarius	Aquarius	1030	Rev. 1	VII	14	No
602	Obv. 2		133	V	19	last appearance	Virgo	Virgo	MLC 1885	Obv. 10	V	18	No
602	Obv. 15		147	VII	30	last appearance	Scorpio	Pisces?	MLC 2915	Obv. 12	VII	24	No
602	Obv. 23		156	V	11	last appearance	Leo	Libra	1032	Obv. 13	V	9	No
602	Obv. 27		160	IX	4	last appearance	Sagittarius	Capricorn	1129	Rev. 6	[IX]	7	No
602	Rev. 1	605 Obv. 11	201	II	9	last appearance	Gemini	Gemini	**1059	Obv. 10	II	13	No
603	Obv. 4		150	V	9	acronychal rising	Aquarius	Aquarius	1030	Obv. 20	V	15 or 16	No
603	Obv. 4		150	VII	8	station	Aquarius	Aquarius	1030	Rev. 1	VII	14	No
604	Obv. 13		172	III	10	acronychal rising	Sagittarius		1028	Obv. 13-14	III	13	No
604	Obv. 29		189	VIII	28	acronychal rising	Cancer		**1055	Rev. 48	VIII	26	No
604a	Line 4		189	VI_2	29	station	Cancer	Gemini	**1055	Rev. 44	VI_2	26	No
606	Obv. 15		129	I	24	last appearance	Taurus	Taurus	1123	Obv. 3	I	24	Yes
606	Obv. 19		133	V	20	last appearance	Virgo	Virgo	MLC 1885	Obv. 10	V	18	No
606	Obv. 32		147	VIII	1	last appearance	Scorpio	Pisces?	MLC 2915	Obv. 12	VII	24	No

605	Obv. 0		189	II	22	last appearance	Gemini	Gemini	**1055	Obv. 12	II	25	No
605	Obv. 1		189	X	27	station	Gemini	Gemini	**1055	Rev. 58	X	24	No
605	Obv. 1		190	III	8	last appearance	Cancer	Cancer	1144	Obv. 4	III	10	No
605	Obv. 8		197	XI	15	last appearance	Aquarius	Aquarius	BM 45716	Rev. 9	XI	19	No
605	Rev. 2		209	XI	3	last appearance	Aquarius	Aquarius	1153	Rev. 3	XI	9	No
607	Obv. 1		209	II	27	station	Aquarius	Aquarius	1154-5	Obv. 4-5	II	26	No

Jupiter	A'						Zodiacal sign						
ACT no			Year	Month	Day	Observation	ACT	Prediction	NSA/Alm no		Month	Day	Dates agree[?]
610	Obv. 4		147	VIII	1	last appearance	Scorpio	Pisces[?]	MLC 2915	Obv. 12	VII	24	No
610	Obv. 7		150	VII	9	station	Aquarius	Aquarius	1030	Rev. 1	VII	14	No
610	Obv. 12		156	V	11	last appearance	Leo	Leo	1032	Obv. 13	V	9	No
610	Rev. 14		184	IX	10	last appearance	Capricorn	Capricorn	1047	Obv. 13	VIII[?]	12	No
610	Rev. 17		188	I	5	last appearance	Aries	Taurus	1051	Obv. 2	I	10	No
610	Rev. 18		189	II	22	last appearance	Gemini	Gemini	**1055	Obv. 12	II	25	No
610	Rev. 19	612 Obv. 2	189	X	25	station	Gemini	Gemini	**1055	Rev. 58	X	24	No
610	Rev. 23		194	III	15	station	Libra	Libra	1057	Obv. 14	III	19	No
611	Obv. 4		183	IX	22	first appearance	Sagittarius	Sagittarius	1137-8	Rev. 6	IX	22	Yes
611	Obv. 8		188	VIII	12	acronychal rising	Taurus		1052	Rev. 7	VIII	11	No
611	Obv. 9		189	III	20	first appearance	Gemini	Gemini	**1055	Obv. 15-16	III	22	No
611	Obv. 9		189	VI_2	26	station	Gemini	Gemini	**1055	Rev. 44	VI_2	26	Yes
611	Obv. 13		194	I	18	acronychal rising	Libra		1057	Obv. 2	I	16	No
611	Obv. 20		201	III	7	first appearance	Gemini	Gemini	**1059	Line 15	III	12	No
611	Obv. 20		201	VII	14	station	Cancer	Cancer	**1059	Line 37	VII	11	No
611	Obv. 20		201	IX	15	acronychal rising	Gemini		**1059	Line 49	IX	11	No
611	Obv. 27		208	X	15	first appearance	Capricorn	Aquarius	BM 32230	Rev. 2	X	19	No
611	Obv. 28		209	XII	3	first appearance	Pisces	Pisces	1153	Rev. 9	XII	10	No
611	Obv. 27		209	II	23	station	Aquarius	Aquarius	1154-5	Obv. 4-5	II	26	No
611	Rev. 13		233	II	29	station	Aquarius	Aquarius	1160	Obv. 4	III	2	No
611	Rev. 14		234	IV	17	station	Aries	Aries	1164-5	Obv. 8	IV	13	No
611	Rev. 16		236	II	15	first appearance	Taurus	Taurus	1174	Obv. 4	II	20	No

611	Rev. 16		236	VI	21	station	Gemini	Gemini	1174	Obv. 12	VI	22	No
611	Rev. 16		236	VIII	22	acronychal rising	Gemini		1174	Rev. 2	VIII	24	No
611	Rev. 24		245	III	17	station	Pisces	Pisces	1179-80	Obv. 5	III	20	No
611	Rev. 24		245	V	18	acronychal rising	Aquarius		1179-80	Obv. 11	V	21	No
611	Rev. 26		247	I	15	first appearance	Aries	Aries	1182	Obv. 2	I	22	No
612	Obv. 0		188	I	5	last appearance	Taurus	Taurus	1051	Obv. 2	I	10	No
612	Obv. 6		194	III	16	station	Libra	Libra	1057	Obv. 14	III	19	No
612	Obv. 9		197	XI	16	last appearance	Aquarius	Aquarius	BM 45716	Rev. 9	XI	19	No
612	Obv. 12		201	II	9	last appearance	Gemini	Gemini	**1059	Line 10	II	13	No
612	Obv. 13		201	XI	13	station	Gemini	Gemini	**1059	Line 60	XI	11	No
612	Rev. 2		209	XI	14	last appearance	Aquarius	Aquarius	1153	Rev. 7	XI	9	No
613a	Obv. 7		209	XI	5	last appearance	Aquarius	Aquarius	1153	Rev. 7	XI	9	No
613a	Obv. 29		233	XI	11	last appearance	Pisces	Pisces	1160	Rev. 8	XI	15	No
613a	Obv. 31		236	I	17	last appearance	Taurus	Taurus	1174	Obv. 1	I	19	No
613a	Rev. 3		245	XI	29	last appearance	Pisces	Pisces	1179-80	Rev. 22	XI	25	No
613a	Rev. 5		248	II	5	last appearance	Taurus	Taurus	1183	Obv. 3	II	6	No

Jupiter	B						Zodiacal sign						
ACT no			Year	Month	Day	Observation	ACT	Prediction	NSA/Alm no		Month	Day	Dates agree[2]
620	Obv. 21		150	V	13	acronychal rising	Aquarius	Aquarius	1030	Obv. 20	V	15 or 16	No
620	Obv. 27		156	XII	12	acronychal rising	Virgo	Virgo	1032	Rev. 13	XII	11[2]	No
620	Rev. 5		172	III	12	acronychal rising	Sagittarius		1038	Obv. 13-14	III	13	No
620	Rev. 21		189	VIII	28	acronychal rising	Gemini		**1055	Rev. 48	VIII	26	No
620	Rev. 25		194	I	17	acronychal rising	Libra		1057	Obv. 2	I	16	No
621a	Obv. 2		188	I	5	last appearance	Aries	Taurus	1051	Obv. 2	I	10	No
621a	Obv. 3		189	II	22	last appearance	Gemini	Gemini	**1055	Obv. 12	II	25	No
621a	Obv. 4		190	III	8	last appearance	Cancer	Cancer	1144	Obv. 4	III	10[2]	No
621a	Obv. 11	622 Obv. 7	197	XI	14	last appearance	Aquarius	Aquarius	BM 45716	Rev. 9	XI	19	No
621a	Obv. 14	622 Obv. 10	201	II	10	last appearance	Gemini	Gemini	**1059	Line 10	II	13	No
622	Obv. 4		194	III	16	station	Libra	Libra	1057	Obv. 14	III	19	No
622	Obv. 11		201	XI	15	station	Gemini	Gemini	**1059	Line 60	XI	11	No

623	Rev. 2	233	XI	9	last appearance	Pisces	Pisces	1160	Rev. 8	XI	15	No
623	Rev. 4	236	I	17	last appearance	Taurus	Taurus	1174	Obv. 1	I	19	No
623	Rev. 13	245	XI	27	last appearance	Pisces	Pisces	1179-80	Rev. 22	XI	25	No
623	Rev. 15	248	II	5	last appearance	Taurus	Taurus	1183	Obv. 3	II	6	No

Jupiter	B'					Zodiacal sign						
ACT no		Year	Month	Day	Observation	ACT	Prediction	NSA/Alm no		Month	Day	Dates agree[2]
640	Obv. 14	156	VII	2	first appearance	Virgo	Virgo	1032	Obv. 17	VI	10	No

Saturn						Zodiacal sign						
ACT no		Year	Month	Day	Observation	ACT	Prediction	NSA/Alm no		Month	Day	Dates agree[2]
702	Rev. 3	178	III	3	acronychal rising			1134	Obv. 3	III	1	No
702	Rev. 4	179	II	26	acronychal rising			1135	Obv. 4	II	23	No
704	Obv. 4	158	VI	19	acronychal rising			1034-5	Rev. 17	VI	18	No

Appendix D: a summary of the records from the Diaries and the Almanacs concerning the dates of planets' entries into zodiacal signs

Appendix D1: Sign entry data from the Astronomical Diaries

Date (Seleucid Era)			Planet	Zodiacal Sign	Tropical Longitude (°)
99	X	9	Venus	Sagittarius	236.93
107	I	10	Venus	Gemini	54.17
108	VIII	23	Venus	Aquarius	292.93
118	VII	5	Mars	Virgo	144.25
118	X	15	Mars	Scorpio	205.37
118	XII	9	Venus	Aquarius	294.88
118	XII	15	Mercury	Aries	357.73
122	II	12	Venus	Taurus	22.69
122	II	6	Mars	Cancer	85.47
125	II	5	Venus	Pisces	321.09
129	II	18	Mars	Leo	142.48
129	VIII	12	Venus	Capricorn	261.78
129	II	24	Mercury	Aquarius	292.67
129	VIII	10	Saturn	Pisces	353.49
130	IV	3	Venus	Cancer	85.41
130	IV	15	Jupiter	Cancer	83.1
133	XII	26	Venus	Taurus	25.9
133	V	11	Mars	Leo	115.22
133	XII	4	Mercury	Pisces	316.73
138	X	15	Venus	Pisces	324.06
138	X	20	Jupiter	Pisces	318
155	VIII	29	Venus	Scorpio	203.21
157	IV	15	Venus	Cancer	87.7
158	V	6	Venus	Libra	176.15
162	VII	29	Mars	Capricorn	266.49
167	VIII	7	Mars	Libra	175.15
167	VIII	22	Mercury	Scorpio	210.37
170	III	20	Mars	Aries	351.64
171	I	19	Mars	Cancer	86.04
171	I	21	Venus	Cancer	83.42
171	VII	3	Venus	Virgo	145.61
171	VII	21	Jupiter	Sagittarius	234.15
171	X	28	Mars	Capricorn	272.7
171	II	7	Venus	Aquarius	292.63
174	II	30	Mars	Taurus	25.37
174	IV	16	Mars	Gemini	56.19
174	X	5	Venus	Sagittarius	236.38
175	XII_2	16	Mercury	Taurus	28.97
175	VI	30	Saturn	Scorpio	205.09
177	VI	9	Mercury	Virgo	147.17
177	VII	4	Venus	Sagittarius	234.27
177	XII	7	Venus	Aquarius	294.5
179	VII	1	Venus	Virgo	145.83
179	VII	28	Venus	Libra	175.02
179	VII	21	Mars	Capricorn	264.66
182	VI	14	Mars	Virgo	145.97
186	V	12	Mercury	Leo	114.53
186	I	2	Venus	Pisces	322.3
186	I	29	Venus	Aries	352.21

Date (Seleucid Era)			Planet	Zodiacal Sign	Tropical Longitude (°)
187	II	13	Mercury	Cancer	84.49
187	III	15	Venus	Cancer	117.08
187	IX	17	Venus	Sagittarius	237.14
187	X	11	Venus	Capricorn	265.51
188	III	8	Venus	Cancer	83.57
188	V	23	Venus	Libra	174.44
189	II	7	Mars	Aries	349.81
189	VI_2	8	Mars	Cancer	85.15
192	II	22	Mars	Virgo	145.91
193	VII	3	Venus	Sagittarius	236.22
194	II	26	Venus	Aries	355.31
194	XII	10	Mars	Aries	351.45
199	VII	26	Mars	Libra	175.76
200	I	14	Mercury	Gemini	57.46
200	II	10	Mars	Pisces	321.07
203	I	16	Venus	Cancer	83.93
203	IV	12	Mercury	Virgo	147.21
204	VIII	3	Mercury	Sagittarius	238.19
204	IX	13	Mercury	Scorpio	234.74
204	XII	2	Venus	Aquarius	322.23
204	XII	23	Venus	Pisces	320.97
204	XII	28	Mars	Cancer	84.44
206	I	2	Venus	Gemini	55.7
206	I	3	Mars	Aries	353.5
206	I	27	Venus	Cancer	85.17
206	II	13	Mercury	Cancer	86.72
206	II	24	Venus	Leo	114.81
208	II	6	Mercury	Gemini	57.03
215	I	7	Venus	Aries	355.39
215	IX	14	Venus	Aquarius	294.82
216	I	6	Mercury	Taurus	20.64
217	I	18	Venus	Gemini	55.2
218	V	7	Venus	Leo	118.55
221	II	7	Jupiter	Pisces	324.6
221	II	13	Venus	Pisces	322.91
224	VI	10	Venus	Leo	116.21
224	XII_2	21	Venus	Taurus	25.25
225	II	11	Venus	Cancer	86.22
225	IV	27	Mercury	Leo	118.83
226	X	23	Venus	Pisces	324.85
226	X	23	Mars	Pisces	325.02
228	III	23	Venus	Leo	113.93
229	X	19	Mercury	Capricorn	264.2
229	X	17	Venus	Aquarius	296.13
229	XII_2	1	Venus	Taurus	25.06
234	II	15	Mercury	Aquarius	292.82
234	II	16	Venus	Taurus	26.15
234	III	12	Venus	Gemini	57.41
234	IV	7	Venus	Cancer	86.63
234	IV	16	Mars	Taurus	25.68
234	V	2	Venus	Leo	117.42
234	VII	13	Mercury	Libra	178.67
238	III	23	Mars	Gemini	56.28

Date (Seleucid Era)			Planet	Zodiacal Sign	Tropical Longitude (°)
239	VIII	18	Venus	Sagittarius	235.32

Appendix D2: Sign entry data from the Almanacs

Date (Seleucid Era)			Planet	Zodiacal Sign	Tropical Longitude (°)
128	VI	6	Jupiter	Aries	25.21
128	VI	23	Mars	Scorpio	209.17
128	VII	24	Venus	Libra	174.94
129	II	2	Mercury	Gemini	55.65
129	II	10	Mars	Taurus	20.5
129	II	14	Saturn	Aries	355.9
129	III	6	Venus	Cancer	85.78
129	IV	7	Mars	Gemini	58.36
129	IV	27	Venus	Virgo	146.33
129	IV	28	Jupiter	Gemini	54.97
129	V	12	Mercury	Virgo	147.54
129	V	28	Mars	Cancer	90.84
129	XI	14	Mars	Leo	143.84
129	XII	15	Venus	Aquarius	291.7
129	XII_2	16	Mercury	Taurus	25.2
129	XII_2	25	Venus	Pisces	331.82
157	III	10	Mars	Taurus	27.34
157	III	18	Mercury	Leo	112.49
157	IV	23	Mars	Gemini	54.78
158	III	23	Mercury	Leo	113.29
158	IX	8	Venus	Scorpio	205.64
158	XI	4	Venus	Capricorn	265.46
160	VI	10	Mars	Scorpio	207.64
162	IV	20	Venus	Leo	116.29
162	IX	9	Mars	Aquarius	296.3
162	IX	19	Venus	Aquarius	298.72
162	V	7	Mars	Scorpio	205.99
162	V	22	Mercury	Virgo	178.13
162	VI	20	Mars	Sagittarius	236.49
178	III	13	Mercury	Cancer	82.97
178	III	25	Venus	Gemini	55.37
178	IV	4	Mercury	Leo	115.25
178	V	3	Mars	Cancer	83.26
178	V	15	Venus	Leo	111.46
178	VI	9	Venus	Virgo	143.75
178	VI	24	Mars	Leo	116.24
178	XI	29	Venus	Aries	354.12
179	II	17	Mercury	Cancer	85.3
179	III	2	Venus	Leo	116.02
179	IX	20	Venus	Sagittarius	237.78
179	XI	8	Mercury	Pisces	328.42
179	XI	25	Mars	Aries	357.76
179	XI	30	Venus	Pisces	322.87
183	IV	8	Mercury	Leo	114.67
183	IX	10	Mercury	Capricorn	263.86
183	IX	21	Venus	Aquarius	293.76
183	IX	23	Saturn	Aquarius	295.3

Date (Seleucid Era)			Planet	Zodiacal Sign	Tropical Longitude (°)
183	VI	14	Venus	Libra	176.11
183	VIII	25	Venus	Capricorn	264.32
183	VIII	27	Mars	Pisces	323.91
183	X	15	Mars	Aries	353.32
183	X	15	Venus	Pisces	322.65
183	XI	13	Venus	Aries	353.81
183	XII	8	Mars	Taurus	26.45
183	XII	14	Mercury	Aries	352.48
183	XII	15	Jupiter	Capricorn	264.44
183	XII	16	Venus	Taurus	26.85
185	XI	5	Mercury	Pisces	325.4
185	XII	25	Mars	Gemini	57.19
189	III	11	Venus	Taurus	25.6
189	III	24	Mars	Taurus	26.47
189	IV	10	Venus	Gemini	55.97
189	V	11	Mars	Gemini	55.26
189	VI	2	Venus	Leo	116.65
190	II	2	Venus	Cancer	85.26
190	II	2	Mars	Leo	115.456
190	II	28	Venus	Leo	115.08
190	XI	20	Saturn	Taurus	25.19
190	XI	29	Mercury	Aries	354.57
198	IV	30	Venus	Libra	175.67
198	IX	1	Mars	Pisces	325.67
198	IX	28	Venus	Sagittarius	235.16
198	VIII	30	Venus	Scorpio	204.5
200	III	21	Mercury	Cancer	84.64
200	X	26	Mars	Taurus	24.82
201	I	18	Mercury	Gemini	55.55
201	III	29	Mercury	Cancer	89.52
201	IX	12	Jupiter	Gemini	84.72
201	IX	25	Mercury	Aquarius	291.32
201	V	4	Venus	Libra	175.91
201	V	22	Jupiter	Cancer	85.19
201	VI	1	Venus	Scorpio	206.3
201	VII	1	Venus	Sagittarius	236.12
201	VIII	17	Mars	Scorpio	208.84
201	XI	29	Saturn	Virgo	176.06
201	XII	1	Venus	Aquarius	292.29
201	XII	17	[Mars]	Aquarius	294.73
209	I	19	Venus	Gemini	54.54
209	II	15	Venus	Cancer	84.95
209	II	30	Mercury	Gemini	59.3
209	III	10	Venus	Leo	115.1
209	IV	4	Mars	Libra	175.29
209	IX	18	Mars	Aquarius	294.05
209	X	9	Mercury	Capricorn	263.96
209	X	25	Saturn	Capricorn	264.92
209	X	28	Mars	Pisces	325.27
209	XI	1	Mercury	Aquarius	293.26
209	XI	28	Venus	Aquarius	291.45
209	XII	5	Mercury	Aries	354.73
209	XII	29	Venus	Pisces	324.72

Date (Seleucid Era)			Planet	Zodiacal Sign	Tropical Longitude (°)
220	XI	11	Venus	Aquarius	326.24
220	XII	5	Mercury	Pisces	320.84
220	XII	19	Mars	Pisces	324.69
220	XII	20	Venus	Pisces	318.33
226	XI	19	Venus	Aries	355.23
226	XII	2	Mars	Aries	353.58
226	XII	15	Mercury	Pisces	320.88
233	III	17	Mars	Leo	116.91
233	IV	4	Venus	Virgo	150.01
233	IX	9	Venus	Scorpio	236.07
233	VI	26	Venus	[Sagittarius]	235.9
233	VII	28	Mercury	Scorpio	210.9
233	VIII	4	Mars	Scorpio	206.6
233	X	6	Jupiter	Pisces	325.32
233	X	25	Venus	Capricorn	263.23
233	X	28	Mars	Capricorn	267.28
233	XII	1	Mercury	Pisces	322.08
233	XII	28	Venus	Pisces	330.75
234	I	4	Saturn	Libra	205.5
234	I	14	Mars	[Pisces]	323.93
234	I	17	Mars	Pisces	326.17
234	I	20	Venus	Aries	356.47
234	I	22	Mercury	Gemini	55.95
234	II	16	Venus	Taurus	26.15
234	II	28	Mars	Aries	355.16
234	III	12	Venus	Gemini	57.41
234	IV	17	Mars	Taurus	26.27
234	V	2	Venus	Leo	117.42
234	V	30	Saturn	Scorpio	204.61
234	VI	28	Jupiter	Pisces	353.81
234	XII	13	Venus	Taurus	25.61
236	I	26	Mars	Aries	356.38
236	II	26	Venus	Cancer	83.93
236	II	29	Jupiter	Gemini	54.65
236	III	9	Mars	Taurus	26.34
236	III	22	Mercury	Leo	116.1
236	III	21	Venus	Leo	114.6
236	IV	15	Venus	Virgo	144
236	IV	25	Mars	Gemini	56.6
236	IX	4	Saturn	Sagittarius	235.49
236	V	11	Venus	Libra	175.7
236	VI	3	Mercury	Virgo	148.21
236	VI	8	Venus	Scorpio	207.13
236	VI	29	Mars	Cancer	86.37
236	VII	2	Venus	Sagittarius	235.73
236	VII	28	Venus	Capricorn	265.86
236	VIII	25	Mars	Gemini	86.87
236	VIII	26	Venus	Aquarius	294.98
236	X	5	Venus	Pisces	324.3
236	X	8	Mercury	Capricorn	269.17
236	X	24	Venus	Aquarius	325.01
236	XI	28	Mercury	Aries	355.3
236	XII	14	Mars	Cancer	84.85

Date (Seleucid Era)			Planet	Zodiacal Sign	Tropical Longitude (°)
237	XI	8	Venus	Pisces	324.25
241	IV	17	Mercury	Virgo	144.25
241	IV	25	Venus	Libra	175.78
244	II	22	Mercury	Cancer	85.95
244	II	25	Venus	Cancer	85.83
244	XII	29	Venus	Pisces	325.03
247	I	22	Venus	Taurus	23.96
247	I	25	Jupiter	Taurus	23.78
247	IV	6	Mercury	Cancer	104.4
247	V	27	Venus	Libra	175.21
247	VIII	10	Venus	Capricorn	300.57
248	I	29	Mercury	Cancer[1]	50.5
248	II	29	Venus	Taurus	22.83
248	VI	5	Venus	Leo	117.04
248	X	7	Venus	Capricorn	267.15
254	XII_2	18	Mercury	Taurus	27.49
282	IX	1	Mars	Sagittarius	237.79
282	X	6	Mercury	Capricorn	268.44
300	II	4	Mars	Aries	356.72
300	II	15	Venus	Gemini	54.97
300	III	11	Venus[?]	Cancer	88.05
300	III	26	Jupiter	Libra	176.95
300	IV	6	Venus	Leo	116.16
300	VII	20	Mercury	Libra	177.32
301	II	27	Mercury	Gemini	58.87
301	III	14	Venus	Gemini	57.89
301	III	16	Mars	Virgo	146.77
301	IV	8	Venus	Cancer	86.62
301	V	4	Venus	Leo	117.12
301	V	5	Mars	Libra	177.2
301	V	28	Venus	Virgo	146.87
303	IV	16	Mercury	Leo	127.36
303	VI	14	Venus	Libra	176.11
305	II	21	Venus	Cancer	86.42
305	II	26	Mercury	Cancer	86.13
305	IV	14	Venus	Virgo	147.45
305	IX	16	Mars	Aquarius	295.74
305	V	16	Mars	Scorpio	207.74
305	VI	12	Venus	Scorpio	207.29
305	VIII	8	Mars	Aquarius[2]	266.2
305	VIII	16	Mercury	Scorpio	206.76
305	X	10	Venus	Sagittarius	233.06
305	X	26	Mars	Pisces	325.9
305	XII	7	Mars	Aries	355.94
305	XII_2	14	Mars	Taurus	22.6
342	I	1	Venus	Gemini	58.08
342	XI	14	Venus	Aquarius	296.37
342	XII	12	Venus	Pisces	329.48
355	I	14	Jupiter	Gemini	56.96
355	III	5	Venus	Taurus	55.52
355	III	14	Mercury	Leo	117.54
355	IV	23	Venus	Cancer	85.18
355	IX	5	Venus	Sagittarius	237.87

Date (Seleucid Era)			Planet	Zodiacal Sign	Tropical Longitude (°)
355	IX	8	Mercury	Sagittarius	240.88
355	IX	19	Mars	Scorpio	206.52
355	IX	29	Mercury	Capricorn	269.06
355	IX	29	Venus	Capricorn	267.86
355	VI	14	Mars	Virgo	147.72
355	VI	21	Venus	Virgo	147.97
355	VII	16	Venus	Libra	178.24
355	VIII	11	Venus	Scorpio	207.93
372	I	2	Venus	Taurus	25.43
372	I	4	Jupiter	Taurus[3]	206.62
372	I	15	Mars	Gemini	63.78
372	II	22	Venus	Cancer	86.67
372	III	18	Venus	Leo	119.48
372	IV	13	Venus	Virgo	147.22
372	V	9	Venus	Libra	177.01
372	V	20	Mercury	Libra	174.37
372	VI	5	Venus	Scorpio	207.34
372	VII	3	Venus	Sagittarius	237.54
372	VII	8	Mercury	Libra	177.37
372	VII	28	Mars	Libra	178.65
372	VIII	3	Venus	Capricorn	267.35
372	X	12	Jupiter	Sagittarius[4]	209.97
372	XI	12	Mercury	Aquarius	295.97
372	XII	2	Venus	Aquarius	293.76
385	I	6	Venus	Gemini	57.75
385	I	14	Mercury	Gemini	58.66
385	II	2	Venus	Cancer	88.75
385	II	28	Venus	Leo	119.01
385	IV	27	Venus	Libra	180.35
385	V	12	Mars	Leo	118.61

[1] Error for Gemini
[2] Error for Capricorn
[3] Error for Scorpio
[4] Error for Scorpio

Appendix E: a summary of records from the non-mathematical astronomical texts which refer to a planet's position within a zodiacal sign

Appendix E1: Beginning and end data from the Astronomical Diaries

Date (Regnal year or Seleucid Era)			Planet	Zodiacal Sign	Beginning / end record	Babylonian longitude (°)
Darius II 5	I	~12	Saturn	Pisces	Unclassified	355.02
Darius II 5	III	9	Jupiter	Gemini	Unclassified	82.33
Darius II 5	IV	~21	Mercury	Leo	Unclassified	128.06
Darius II 5	XII	29	Mercury	Aries	Unclassified	14.17
Darius II 5	XII_2	~1	Saturn	Pisces	End	4.27
Darius II 5	XII_2	21	Venus	Aries	Unclassified	24.59
Arta II 29	XI	11	Mars	Capricorn	Unclassified	293.69
Arta II 29	XII_2	7	Venus	Aries	Beginning	357.34
Alex III 13	II	28	Jupiter	Gemini	Beginning	59.57
Alex III 13	III	3	Mercury	Cancer	Unclassified	88.4
Alex III 13	III	18	Saturn	Gemini	Unclassified	73.86
Alex III 13	IV	15	Mercury	Leo	Unclassified	141.26
Alex III 13	V	18	Venus	Virgo	Unclassified	181.1
2	V	24	Jupiter	Virgo	Beginning	158.14
2	VIII	21	Mercury	Sagittarius	Unclassified	244.02
3	I	8	Saturn	Sagittarius	Unclassified	264.68
3	I	19	Mercury	Taurus	Unclassified	55.44
3	V	22	Venus	Virgo	End	175.22
3	VI	3	Mercury	Libra	Unclassified	190.06
3	VI	12	Venus	Virgo	Unclassified	164.97
18	II	25	Mars	Taurus	Beginning	30.51
25	VII	~7	Saturn	Libra	Beginning	184.74
30	X	3	Mercury	Capricorn	Unclassified	294.7
30	X	5	Mars	Sagittarius	End	268.58
51	VI	~22	Mercury	Libra	Beginning	184.48
55	III	10	Jupiter	Aquarius	Unclassified	324.54
55	XI	1	Mercury	Aquarius	Unclassified	317.21
55	XI	15	Saturn	Libra	Unclassified	198.23
55	XI	16	Mercury	Aquarius	Unclassified	304.68
55	XI	19	Jupiter	Pisces	Beginning	334.68
56	I	27	Mercury	Taurus	Unclassified	46.96
56	II	23	Mars	Gemini	Unclassified	72
56	VI_2	~18	Mercury	Libra	Beginning	181.53
57	IX	~20	Mercury	Capricorn	Unclassified	283.63
57	IX	~29	Mercury	Sagittarius	End	273.03
57	X	18	Venus	Aquarius	Unclassified	304.29
57	X	19	Venus	Aquarius	Unclassified	303.45
57	XI	13	Mercury	Aquarius	Unclassified	309.71
58	VII	1	Jupiter	Gemini	Unclassified	71.9
58	VII	3	Mercury	Virgo	Unclassified	178.45
58	VII	~10	Venus	Libra	Unclassified	187.52
58	VII	~18	Saturn	Scorpio	Unclassified	221.09
58	VIII	23	Saturn	Scorpio	Unclassified	225.04
58	XII_2	~9	Mercury	Aries	End	20.93
60	VII	27	Mars	Libra	Unclassified	205.99
60	VIII	6	Saturn	Sagittarius	Beginning	243.7
60	VIII	13	Mercury	Scorpio	Unclassified	223.25

Date (Regnal year or Seleucid Era)			Planet	Zodiacal Sign	Beginning / end record	Babylonian longitude (°)
60	VIII	17	Jupiter	Leo	Unclassified	135.46
60	XII	20	Mercury	Pisces	Unclassified	334.24
60	XII	21	Jupiter	Leo	Unclassified	124.35
60	XII	29	Venus	Aries	Unclassified	15.46
62	IX	~20	Mercury	Capricorn	Unclassified	295.97
62	IX	27	Saturn	Capricorn	Beginning	270.31
62	X	~11	Mercury	Aquarius	Unclassified	309.02
62	XII	~4	Mercury	Pisces	Unclassified	333.43
65	I	17	Venus	Taurus	Unclassified	48.98
65	I	~18	Mars	Aries	Unclassified	16.49
65	II	11	Saturn	Aquarius	Beginning	300.13
65	VI	12	Mercury	Virgo	Unclassified	168.99
70	II	~16	Jupiter	Taurus	End	58.94
70	II	~28	Mercury	Gemini	Unclassified	64.31
79	VII	~14	Jupiter	Aquarius	End	324.98
79	VIII	9	Mercury	Sagittarius	Unclassified	249.59
79	VIII	14	Mercury	Sagittarius	Unclassified	247.63
79	VIII	28	Mercury	Scorpio	Unclassified	233.4
79	X	8	Mercury	Capricorn	Unclassified	277.44
79	XI	~27	Jupiter	Pisces	Unclassified	345.61
79	XII	29	Jupiter	Pisces	Unclassified	353.26
81	I	13	Venus	Taurus	Unclassified	48.87
81	I	~18	Jupiter	Taurus	Beginning	29.37
81	I	24	Mercury	Gemini	Beginning	64.79
86	III	26	Mercury	Leo	Unclassified	135.18
86	IV	14	Mars	Cancer	Unclassified	112.2
86	IV	21	Mercury	Leo	Beginning	131.56
90	IX	4	Mercury	Capricorn	Beginning	271.86
102	I	7	Saturn	Aries	End	26.98
102	II	22	Saturn	Taurus	Beginning	32.79
102	III	4	Mercury	Gemini	Unclassified	81.08
102	IV	9	Mercury	Gemini	Unclassified	81.86
102	IV	23	Mercury	Cancer	Unclassified	106.69
102	VI	5	Mercury	Virgo	Unclassified	176.73
114	VII	12	Saturn	Libra	Unclassified	192.2
114	VII	19	Mercury	Libra	Unclassified	200.07
114	VIII	25	Venus	Sagittarius	Unclassified	260.91
114	VIII	27	Mercury	Sagittarius	Unclassified	242.35
114	X	25	Mercury	Aquarius	Unclassified	320.79
114	X	28	Jupiter	Aquarius	Unclassified	323.04
114	XI	14	Mercury	Aquarius	Unclassified	307.4
114	XII	3	Jupiter	Pisces	Beginning	331.21
114	XII	13	Mercury	Pisces	Unclassified	333
118	II	15	Jupiter	Gemini	Unclassified	68.5
118	VII	~15	Venus	Libra	Unclassified	214
118	VIII	2	Venus	Libra	Unclassified	204.8
118	VIII	~9	Saturn	Scorpio	Unclassified	233.54
118	VIII	~29	Mercury	Sagittarius	Unclassified	256.76
118	IX	14	Saturn	Scorpio	End	237.49
120	IV	25	Jupiter	Leo	Unclassified	134.46
120	IV	~22	Mercury	Cancer	Unclassified	105.01
120	VI	7	Mars	Leo	End	150.04
120	VIII	8	Mercury	Libra	End	208.92

Date (Regnal year or Seleucid Era)			Planet	Zodiacal Sign	Beginning / end record	Babylonian longitude (°)
120	VIII	~22	Saturn	Sagittarius	Unclassified	256.33
121	II	~6	Mercury	Taurus	End	51.35
121	III	16	Mercury	Cancer	Beginning	95.59
121	IV	~17	Mercury	Gemini	Unclassified	88.57
121	IX	~19	Saturn	Capricorn	Beginning	267.54
121	XII	27	Mercury	Pisces	Unclassified	332.87
122	II	~8	Mercury	Gemini	Unclassified	75.96
122	VII	1	Mars	Libra	Beginning	175.95
123	I	1	Mercury	Taurus	Beginning	30.72
124	VIII	3	Mercury	Sagittarius	Unclassified	256.77
124	VIII	~11	Jupiter	Sagittarius	Unclassified	257.39
124	XI	~15	Mercury	Pisces	Unclassified	350.59
124	XII	3	Venus	Pisces	End	355.29
125	X	18	Saturn	Aquarius	Unclassified	314.16
125	XI	9	Jupiter	Aquarius	Unclassified	301.67
125	XII	1	Mercury	Pisces	End	358.77
126	XII	22	Saturn	Pisces	Beginning	331.63
128	II	~13	Venus	Gemini	Unclassified	64.76
128	II	30	Venus	Gemini	Beginning	55.67
129	I	23	Saturn	Pisces	End	359.24
129	I	~14	Venus	Aries	End	27.7
129	II	23	Mercury	Gemini	Unclassified	65.37
129	VIII	4	Mercury	Libra	Unclassified	202.86
129	X	17	Mercury	Capricorn	Unclassified	282.6
133	XI	11	Mercury	Pisces	Unclassified	330.63
133	XII	29	Mercury	Pisces	End	350.92
136	IX	1	Mercury	Sagittarius	End	269
143	V	~19	Saturn	Libra	Beginning	182.07
143	V	24	Venus	Virgo	End	180.64
143	V	27	Mercury	Virgo	Unclassified	157.08
143	VI	~16	Mars	Scorpio	Beginning	214.37
143	VI	23	Mercury	Libra	Beginning	189.47
143	VI	~29	Saturn	Libra	Unclassified	186.81
143	VIII	~15	Mercury	Sagittarius	Unclassified	268.34
143	IX	~2	Mercury	Capricorn	Unclassified	275.57
144	II	18	Venus	Taurus	End	52.82
148	VIII	~11	Saturn	Scorpio	End	238.73
148	VIII	~18	Mercury	Scorpio	Unclassified	216.76
148	X	19	Jupiter	Capricorn	Unclassified	274.5
148	X	~20	Mercury	Aquarius	Unclassified	302.89
148	XII	~14	Mercury	Aquarius	End	321.45
148	XII	16	Venus	Pisces	Unclassified	351.57
148	XII	22	Venus	Pisces	Unclassified	347.61
150	I	~18	Mercury	Taurus	Unclassified	40.92
150	I	~22	Mars	Taurus	Unclassified	53.81
150	V	8	Saturn	Sagittarius	Unclassified	254.67
150	V	~15	Mercury	Virgo	Unclassified	165.16
150	VI	~7	Mercury	Leo	End	150.36
153	I	~2	Venus	Aries	Unclassified	22
153	V	~15	Mercury	Leo	Unclassified	133.48
153	X	2	Venus	Capricorn	Beginning	272.33
165	IX	~19	Mercury	Sagittarius	Unclassified	266.12
165	X	10	Venus	Aquarius	Unclassified	308.33

Date (Regnal year or Seleucid Era)			Planet	Zodiacal Sign	Beginning / end record	Babylonian longitude (°)
165	X	25	Mercury	Pisces	Beginning	328.78
167	VI	~17	Venus	Virgo	End	179.83
167	VII	~27	Mercury	Libra	Unclassified	194.94
167	IX	~1	Mercury	Scorpio	Unclassified	227.46
170	I	~23	Mercury	Taurus	Unclassified	35.37
170	VI_2	~8	Mercury	Virgo	Unclassified	173.37
170	VI_2	~20	Jupiter	Scorpio	Beginning	210.12
170	VII	22	Jupiter	Scorpio	Unclassified	217.25
170	VIII	~17	Mercury	Sagittarius	Unclassified	265.94
170	XII	~11	Mercury	Aries	Unclassified	17.35
171	IV	~4	Venus	Cancer	End	122.98
171	IV	19	Venus	Cancer	Unclassified	114.07
171	IX	~7	Jupiter	Sagittarius	Unclassified	249.45
171	XI	14	Mercury	Pisces	Unclassified	343.61
175	VII	6	Mercury	Virgo	Unclassified	170.97
175	VII	~10	Mars	Scorpio	Unclassified	217.44
175	VII	~13	Saturn	Scorpio	Beginning	211.51
175	X	10	Mercury	Capricorn	Unclassified	290.17
178	XI	21	Mercury	Pisces	Beginning	331.61
178	XII	~16	Mercury	Pisces	End	349.94
179	VII	~29	Mercury	Scorpio	Beginning	212.93
179	VIII	~15	Saturn	Sagittarius	Unclassified	256.53
179	IX	~13	Mercury	Sagittarius	Unclassified	259.26
179	X	~14	Mercury	Aquarius	Unclassified	312.08
179	XII	14	Mars	Aries	Unclassified	16.49
179	XII	29	Mercury	Pisces	Unclassified	352.61
182	I	~26	Mercury	Taurus	End	59.34
182	IV	14	Mercury	Leo	Unclassified	136
182	VI	~9	Mars	Leo	Unclassified	147.75
182	VI	~22	Mercury	Virgo	Unclassified	167.35
187	II	22	Mercury	Cancer	Beginning	90.6
187	III	~22	Mercury	Gemini	Unclassified	83.73
187	III	~27	Venus	Cancer	Unclassified	118
187	VI	1	Mercury	Libra	Unclassified	192.96
187	VI	10	Mercury	Libra	Unclassified	201.88
187	IX	~21	Mercury	Capricorn	Unclassified	293.44
187	X	2	Mercury	Aquarius	Unclassified	307.32
187	X	~28	Mercury	Capricorn	End	295.71
193	I	30	Mercury	Gemini	Beginning	61.08
193	II	7	Saturn	Gemini	Unclassified	64.89
193	VII	~12	Jupiter	Libra	Unclassified	194.61
193	VII	21	Mercury	Libra	Unclassified	198.77
194	VIII	~17	Venus	Scorpio	End	238.49
194	VIII	~23	Jupiter	Scorpio	Unclassified	225.34
194	XII	14	Mercury	Aquarius	End	323.1
201	V	~4	Mercury	Virgo	Unclassified	158.19
201	V	~14	Saturn	Virgo	Unclassified	170.43
201	V	~27	Mercury	Virgo	End	186.73
203	III	12	Mercury	Cancer	Unclassified	108.76
203	III	~20	Venus	Cancer	Unclassified	113.02
203	IV	~15	Mars	Leo	End	149.56
203	IV	~21	Mercury	Virgo	Beginning	157.81
203	V	8	Jupiter	Leo	Unclassified	139.1

Date (Regnal year or Seleucid Era)			Planet	Zodiacal Sign	Beginning / end record	Babylonian longitude (°)
203	VII	~10	Saturn	Libra	Unclassified	198.6
204	IV	~18	Mercury	Leo	Unclassified	141.34
204	VIII	9	Saturn	Scorpio	Beginning	210.65
204	XI	~22	Venus	Pisces	Beginning	331.92
206	I	~24	Mercury	Gemini	Unclassified	61.96
206	III	~6	Mercury	Cancer	Unclassified	101.85
206	V	~28	Venus	Virgo	End	187.19
206	VII	~14	Jupiter	Scorpio	Unclassified	223.81
206	VII	~15	Saturn	Scorpio	Unclassified	228.73
206	VII	~17	Mercury	Libra	Unclassified	201.57
212	VIII	2	Mercury	Libra	End	211.28
212	IX	10	Mercury	Sagittarius	Unclassified	249.09
212	X	~2	Saturn	Capricorn	End	297.3
215	II	~1	Mercury	Taurus	End	56.05
216	V	20	Mercury	Virgo	Unclassified	161.03
216	VI	16	Mercury	Leo	End	146.73
218	IV	~17	Mars	Leo	Unclassified	135.91
218	V	~4	Mercury	Cancer	End	114
218	V	20	Venus	Leo	Unclassified	139.06
218	V	~22	Mercury	Leo	Unclassified	137.81
224	VI	~11	Mercury	Leo	End	150.5
224	XII_2	1	Venus	Aries	Unclassified	4.89
224	XII_2	16	Mercury	Pisces	End	346.56
225	V	~4	Mercury	Leo	Unclassified	133.29
225	VIII	1	Mercury	Scorpio	Beginning	212.35
225	VIII	28	Venus	Sagittarius	Unclassified	247.7
234	I	~5	Mercury	Taurus	Unclassified	31.44
234	II	~13	Mercury	Gemini	Unclassified	71.37
234	III	18	Mercury	Gemini	Unclassified	70.32
234	IV	~2	Mercury	Gemini	End	91.28
234	V	13	Mercury	Virgo	Unclassified	164.54
234	V	~13	Venus	Leo	Unclassified	135.22
234	VI	2	Mercury	Virgo	End	186.08
234	VII	~30	Mercury	Libra	Unclassified	208.59
234	VIII	~2	Venus	Scorpio	Unclassified	232.51
234	VIII	~12	Saturn	Scorpio	Unclassified	216.49
234	XI	~28	Mercury	Aquarius	Unclassified	316
238	III	~16	Mercury	Leo	Beginning	129.9
238	III	17	Jupiter	Cancer	Unclassified	90.26
249	I	26	Saturn	Aries	End	28.79

Appendix E2: Beginning and end data from the Goal-Year Texts

Date (Seleucid Era)			Planet	Zodiacal Sign	Beginning / end record	Babylonian longitude (°)
8	VII	14	Jupiter	Pisces	Beginning	330.99
10	I	19	Jupiter	Taurus	Unclassified	35.27
15	V	~24	Mars	Virgo	Unclassified	170.79
15	XI	~25	Mars	Aquarius	Unclassified	302.87
17	VII	~7	Mars	Scorpio	Unclassified	219.35
19	X	26	Jupiter	Aquarius	End	319.99
20	XII_2	21	Jupiter	Aries	Unclassified	5.03

Date (Seleucid Era)			Planet	Zodiacal Sign	Beginning / end record	Babylonian longitude (°)
22	VI	2	Saturn	Leo	Unclassified	148.73
25	IV	~18	Jupiter	Leo	Unclassified	130.26
32	IV	29	Saturn	Sagittarius	Unclassified	252.97
32	IX	19	Saturn	Sagittarius	Unclassified	252.97
35	I	~22	Mercury	Gemini	Beginning	58.79
35	III	3	Mercury	Cancer	Unclassified	105.81
35	IV	21	Mercury	Cancer	Unclassified	122.15
35	IX	21	Saturn	Capricorn	Unclassified	294.44
35	X	23	Mercury	Aquarius	Unclassified	322.19
35	XI	2	Saturn	Capricorn	End	298.86
35	XI	~11	Mercury	Aquarius	Unclassified	309.22
36	II	~8	Saturn	Aquarius	Unclassified	305.84
37	XI	~21	Saturn	Aquarius	Unclassified	324.06
45	I	18	Mercury	Taurus	Unclassified	38.11
45	IV	9	Mercury	Cancer	Unclassified	114.09
45	V	20	Mercury	Virgo	Beginning	161.84
45	VI	14	Mercury	Leo	End	147.06
45	VII	6	Mercury	Virgo	Unclassified	174.18
45	VIII	29	Mercury	Sagittarius	Unclassified	242.05
45	IX	14	Mercury	Sagittarius	Unclassified	267.19
45	IX	~26	Mercury	Sagittarius	Unclassified	254.08
45	XI	10	Mercury	Capricorn	Unclassified	292.61
45	XII_2	~10	Mercury	Aries	Unclassified	18.64
49	II	27	Mercury	Cancer	Unclassified	88.31
49	III	~20	Mercury	Gemini	End	80.34
49	VI	10	Mercury	Libra	Unclassified	199.61
49	VII	~7	Mercury	Libra	Unclassified	188.77
49	VIII	11	Mercury	Scorpio	Unclassified	225.54
49	IX	22	Mercury	Capricorn	Unclassified	289.98
49	XI	2	Mercury	Capricorn	Unclassified	294.27
50	I	7	Mercury	Taurus	Beginning	27.34
50	III	13	Mercury	Gemini	Beginning	61.75
61	IX	27	Mars	Taurus	Unclassified	50.28
63	V	~22	Saturn	Capricorn	Beginning	270.5
64	VIII	~12	Jupiter	Scorpio	Unclassified	233.94
64	IX	14	Jupiter	Scorpio	End	241.23
69	II	3	Jupiter	Aries	Unclassified	24.9
73	I	~11	Venus	Taurus	Unclassified	44.63
73	X	10	Venus	Aquarius	Unclassified	299.42
76	I	2	Mercury	Taurus	Unclassified	37.27
76	V	21	Mercury	Virgo	Unclassified	182.79
76	VI	24	Mercury	Virgo	Unclassified	177.45
76	VII	~25	Mercury	Libra	Unclassified	210.22
76	IX	10	Mercury	Capricorn	Unclassified	279.97
76	XI	24	Mercury	Aquarius	Unclassified	319.38
76	XII	26	Mercury	Aries	Unclassified	19
81	IV	~18	Saturn	Leo	Unclassified	144.89
81	V	25	Saturn	Leo	End	149.32
83	I	~4	Venus	Aries	Unclassified	16.39
83	V	11	Mercury	Leo	End	150
83	V	13	Venus	Leo	Unclassified	150.63
83	VI	~1	Saturn	Virgo	Unclassified	169.17
83	VI	3	Venus	Leo	Unclassified	140.07

Date (Seleucid Era)			Planet	Zodiacal Sign	Beginning / end record	Babylonian longitude (°)
83	VII	6	Mercury	Virgo	Unclassified	170.33
83	VII	12	Saturn	Virgo	Unclassified	174.07
83	VIII	~4	Mercury	Libra	End	201.23
83	X	10	Mercury	Capricorn	Unclassified	290.32
83	X	~24	Mercury	Capricorn	Unclassified	276.35
85	VI	~20	Saturn	Libra	Unclassified	193.21
87	VII	~2	Jupiter	Libra	End	211.15
88	III	3	Venus	Gemini	Unclassified	76.45
89	III	27	Mars	Aquarius	Unclassified	325.23
89	V	27	Mars	Aquarius	Unclassified	314.43
89	IX	7	Jupiter	Capricorn	Unclassified	278.17
92	IV	~10	Mars	Leo	Unclassified	142.01
94	I	15	Mercury	Aries	Unclassified	356.86
94	IV	2	Mercury	Cancer	Unclassified	108.55
94	IV	26	Mercury	Cancer	Unclassified	98.56
94	VII	12	Mercury	Libra	Unclassified	204.54
94	VIII	21	Mercury	Sagittarius	Unclassified	247.19
94	IX	27	Mercury	Aquarius	Unclassified	305.54
94	X	~18	Mercury	Aquarius	Unclassified	325.69
94	XI	7	Mercury	Aquarius	Unclassified	312.47
94	XII	~10	Mercury	Pisces	Unclassified	342.86
96	I	7	Mercury	Taurus	Unclassified	29.75
96	III	21	Mercury	Gemini	Unclassified	69.78
96	IV	7	Mercury	Gemini	Unclassified	95.29
96	V	11	Mercury	Leo	End	157.07
96	VI	~6	Mercury	Virgo	End	185.34
96	VII	2	Mercury	Virgo	Unclassified	172.96
96	VIII	~2	Mercury	Libra	Unclassified	206.88
96	IX	18	Mercury	Capricorn	Unclassified	279.39
96	X	21	Mercury	Capricorn	Unclassified	278.31
97	V	30	Jupiter	Virgo	Unclassified	161.8
98	V	23	Mercury	Leo	Unclassified	140.62
99	XII	~17	Saturn	Pisces	End	359.27
110	VII	29	Jupiter	Libra	Unclassified	196.45
112	VI	27	Saturn	Virgo	Unclassified	168.6
114	IV	10	Mercury	Cancer	Unclassified	99.52
115	VIII	7	Jupiter	Pisces	Unclassified	340.02
115	XII	~8	Mars	Pisces	End	357.21
115	XII	~20	Jupiter	Aries	Beginning	0.54
122	I	2	Mercury	Taurus	Unclassified	37.26
122	X	15	Mercury	Capricorn	Unclassified	282.97
122	XI	~17	Mercury	Aquarius	Unclassified	310.14
123	I	1	Mercury	Aries	End	30.72
123	VII	~24	Jupiter	Scorpio	Unclassified	224.32
123	VIII	25	Jupiter	Scorpio	Unclassified	231.32
125	IV	14	Mercury	Leo	Unclassified	142.91
125	V	14	Mercury	Leo	Unclassified	130.63
125	VI	~2	Mercury	Virgo	Beginning	156.69
125	VIII	1	Mercury	Scorpio	Unclassified	244.93
125	VIII	15	Mercury	Sagittarius	Unclassified	247.3
125	X	8	Mercury	Capricorn	Unclassified	277.49
125	XI	14	Mercury	Pisces	Unclassified	341.83
125	XII	~1	Mercury	Pisces	End	358.77

Date (Seleucid Era)			Planet	Zodiacal Sign	Beginning / end record	Babylonian longitude (°)
127	III	~22	Venus	Cancer	Unclassified	100.36
127	VI	1	Venus	Libra	Beginning	183.26
129	II	28	Mars	Taurus	Unclassified	38.22
132	XI	30	Venus	Pisces	Unclassified	352.09
133	I	17	Saturn	Taurus	Unclassified	49.47
135	II	17	Saturn	Gemini	Unclassified	79.25
135	III	9	Mercury	Gemini	Unclassified	75.7
135	V	~7	Mercury	Virgo	Unclassified	173.02
135	VI	22	Mercury	Virgo	End	179.84
135	XI	24	Mercury	Pisces	Beginning	330.47
136	II	10	Venus	Gemini	Unclassified	61.81
136	II	21	Venus	Gemini	Beginning	55.21
136	XI	5	Venus	Aquarius	Unclassified	306.98
140	I	15	Venus	Aries	Unclassified	7.46
140	I	16	Mercury	Aries	Unclassified	0.1
140	II	17	Mercury	Gemini	Unclassified	61.63
140	V	17	Mercury	Leo	Beginning	126.88
140	XI	18	Mercury	Capricorn	End	325.75
142	II	13	Mercury	Gemini	Unclassified	70.05
146	II	9	Mercury	Gemini	Unclassified	82.58
146	VII	29	Mercury	Scorpio	Beginning	213.56
146	IX	~5	Mercury	Sagittarius	Unclassified	252.36
146	X	14	Mercury	Aquarius	Unclassified	318.38
146	X	27	Mercury	Pisces	Beginning	335.48
146	XII	23	Mercury	Pisces	End	348.93
148	I	26	Mercury	Taurus	Unclassified	46.98
148	IV	7	Mercury	Gemini	Unclassified	80.72
148	IV	23	Mercury	Cancer	Unclassified	108.03
148	VI	4	Mercury	Virgo	Unclassified	176.82
148	VII	18	Mercury	Libra	Beginning	182.02
148	IX	21	Saturn	Sagittarius	Beginning	243.37
148	X	5	Mercury	Capricorn	Unclassified	290.11
148	XI	10	Mercury	Capricorn	Unclassified	287.86
148	XII	17	Mercury	Pisces	Unclassified	326.31
148	XII_2	23	Mercury	Taurus	Unclassified	34.59
152	II	~3	Venus	Taurus	End	57.55
152	II	15	Venus	Taurus	Unclassified	50.43
152	V	~17	Mercury	Leo	Unclassified	141.41
152	VIII	14	Mercury	Scorpio	Unclassified	223.14
152	X	~26	Venus	Aquarius	Beginning	301.86
152	XI	1	Mercury	Pisces	Beginning	329.54
152	XII	23	Mercury	Pisces	Unclassified	338.28
153	II	2	Jupiter	Taurus	Unclassified	50.98
154	II	~16	Jupiter	Gemini	Unclassified	84.09
154	III	18	Jupiter	Cancer	Beginning	90.99
156	II	2	Mercury	Taurus	End	53.41
156	III	13	Mercury	Gemini	Unclassified	58.97
156	III	~25	Mercury	Gemini	Unclassified	80.09
156	IV	24	Mercury	Leo	Unclassified	134.19
156	V	26	Mercury	Virgo	Unclassified	173.11
156	IX	11	Mercury	Sagittarius	End	269.61
156	X	~8	Mercury	Sagittarius	Unclassified	266.13
156	XII	28	Mercury	Aries	Unclassified	11.59

Date (Seleucid Era)			Planet	Zodiacal Sign	Beginning / end record	Babylonian longitude (°)
156	XII_2	~26	Mercury	Taurus	Beginning	32.71
160	I	29	Venus	Taurus	End	55.11
160	II	11	Venus	Taurus	Unclassified	48.05
160	XII	29	Venus	Aries	Unclassified	20.11
161	I	21	Mercury	Taurus	Unclassified	47.9
161	III	2	Mercury	Gemini	End	83.67
161	IV	1	Mercury	Gemini	Unclassified	80.11
161	X	1	Mercury	Capricorn	Unclassified	291.25
161	XI	4	Mercury	Capricorn	Unclassified	290.84
163	III	13	Saturn	Gemini	Beginning	63.1
163	IV	~6	Venus	Leo	Beginning	125.97
163	XII	~20	Venus	Pisces	Unclassified	346.36
165	III	5	Jupiter	Taurus	End	65.72
176	I	~11	Mercury	Taurus	Unclassified	47.1
176	II	23	Mercury	Taurus	End	58.01
176	II	29	Mercury	Gemini	Unclassified	68.47
176	IV	2	Mercury	Leo	Unclassified	130.73
176	VI	1	Mercury	Virgo	Unclassified	155.1
176	VIII	19	Mercury	Sagittarius	Unclassified	268.4
176	XII	5	Mercury	Aries	Unclassified	7.72
177	VIII	4	Saturn	Scorpio	Unclassified	234.62
177	IX	6	Saturn	Scorpio	End	238.35
179	II	8	Mercury	Gemini	Unclassified	74.15
179	IV	16	Mercury	Cancer	Unclassified	106.7
179	V	~5	Mercury	Leo	Unclassified	133.28
184	I	~17	Venus	Taurus	Unclassified	49.02
184	X	7	Venus	Capricorn	Unclassified	287.89
184	XII	23	Venus	Aries	Unclassified	20.56
186	VI	~6	Venus	Leo	End	147.99
186	VIII	23	Venus	Sagittarius	Beginning	242.95
190	III	19	Mercury	Cancer	Unclassified	113.33
190	IV	~23	Mercury	Leo	Unclassified	154.85
190	V	24	Mercury	Leo	Unclassified	142.17
190	VI	~3	Venus	Libra	Beginning	192.27
190	VIII	~8	Mercury	Sagittarius	Unclassified	251.87
190	VIII	~23	Mercury	Sagittarius	Unclassified	261.39
190	IX	~7	Mercury	Sagittarius	Unclassified	247.16
190	X	~13	Mercury	Capricorn	Unclassified	279.09
190	XI	24	Mercury	Pisces	Unclassified	350.61
190	XII	~17	Mercury	Aries	Unclassified	12.19
214	VI	15	Venus	Virgo	Unclassified	173.49
217	VIII	~23	Venus	Sagittarius	Unclassified	255.59
217	VIII	~27	Venus	Sagittarius	Unclassified	252.99
228	II	~11	Venus	Gemini	Unclassified	67.84
228	XI	~10	Venus	Aquarius	End	325.46
228	XI	15	Venus	Aquarius	Unclassified	322.15

Appendix E3: Beginning and end data from the Normal Star Almanacs

Date (Seleucid Era)			Planet	Zodiacal Sign	Beginning / end	Babylonian longitude (°)
82	IV	16	Mercury	Cancer	Unclassified	110.35
82	XI	10	Mars	Leo	End	155
82	XII	9	Mercury	Pisces	Beginning	326.57
92	XII	21	Venus	Aries	Beginning	2.88
93	I	4	Jupiter	Aries	End	26.96
93	II	22	Mercury	Gemini	Unclassified	75.49
93	IV	8	Mercury	Leo	Unclassified	127.44
93	X	29	Saturn	Capricorn	Unclassified	287.91
93	XI	17	Venus	Pisces	Unclassified	330.68
101	IV	1	Mars	Gemini	End	90.22
104	IX	7	Jupiter	Aries	Unclassified	11.44
104	IX	12	Mercury	Sagittarius	End	268.74
104	IX	22	Mercury	Sagittarius	Unclassified	256.94
105	I	24	Jupiter	Taurus	Unclassified	39.08
105	V	1	Mercury	Leo	Unclassified	133.86
105	V	20	Jupiter	Taurus	End	56.69
105	V	27	Mercury	Virgo	Unclassified	165.48
108	IV	4	Jupiter	Leo	Unclassified	129.41
108	IV	10	Mercury	Cancer	Unclassified	117.98
108	IV	18	Saturn	Cancer	Unclassified	116.91
108	V	4	Jupiter	Leo	Unclassified	135.7
108	IX	5	Jupiter	Virgo	Beginning	152.45
108	IX	20	Mercury	Capricorn	Unclassified	296.04
111	II	26	Mercury	Gemini	Unclassified	74.57
111	III	13	Mercury	Cancer	Unclassified	108.74
111	III	28	Venus	Cancer	Unclassified	102.92
111	IV	24	Saturn	Virgo	Beginning	151.59
111	V	19	Mercury	Leo	Unclassified	143.06
111	VI	12	Venus	Libra	Unclassified	193.38
111	VI	12	Mercury	Virgo	Unclassified	172.44
111	VIII	10	Mercury	Sagittarius	Unclassified	257.78
111	X	1	Saturn	Virgo	Unclassified	163.17
111	XI	20	Mercury	Pisces	Unclassified	349.65
111	XII	10	Jupiter	Sagittarius	Unclassified	244.63
111	XII	16	Mercury	Aries	Unclassified	13.99
111	XII	28	Mars	Pisces	End	351.59
116	IV	14	Mercury	Leo	Unclassified	147.52
116	IV	26	Jupiter	Aries	End	26.42
116	IX	16	Mercury	Capricorn	Unclassified	285.51
116	IX	27	Mercury	Capricorn	Unclassified	273.92
137	IV	26	Saturn	Cancer	Unclassified	109.59
137	VIII	29	Saturn	Cancer	End	118.07
158	I	10	Mercury	Aries	Beginning	5.22
158	IV	20?	Saturn	Pisces	End	358.68
158	VI	5	Mercury	Leo	End	155.82
172	II	13	Saturn	Virgo	Unclassified	169.69
172	V	2	Mercury	Cancer	Unclassified	113.04
172	VI	2	Saturn	Virgo	End	176.36
172	X	1	Mercury	Sagittarius	Unclassified	261.88
173	VIII	21?	Mercury	Sagittarius	Beginning	241.51
173	VIII	21?	Mars	Sagittarius	Beginning	248.67

Date (Seleucid Era)			Planet	Zodiacal Sign	Beginning / end	Babylonian longitude (°)
173	X	5	Venus	Aquarius	Unclassified	303.89
173	X	17	Mercury	Aquarius	End	324.58
173	X	23	Mars	Aquarius	Beginning	296.09
173	XI	5	Saturn	Libra	Unclassified	199.64
173	XI	11	Mercury	Aquarius	Unclassified	310.56
173	XII	12	Mercury	Pisces	Unclassified	340.32
188	I	7	Mercury	Taurus	Unclassified?	33.49
188	I	10	Jupiter	Taurus	Beginning	31.05
188	I	14	Saturn	Aries	Beginning	0.06
188	II	12	Jupiter	Taurus	Unclassified	38.5
188	II	13	Mercury	Gemini	Unclassified	70.81
188	III	17	Mercury	Gemini	Unclassified	67.95
188	VI	29	Mercury	Virgo	Unclassified?	175.28
188	VII	30	Mercury	Libra	Unclassified	205.39
188	X	8	Mercury	Aquarius	Beginning	290.63
188	X	20	Mercury	Capricorn	Unclassified	278.94
188	XI	28	Mercury	Aquarius	Unclassified	314.34
188	XI	29	Venus	Pisces	Unclassified	338.01
188	XII	1	Venus	Pisces	Unclassified	336.54
188	XII	26	Saturn	Aries	Unclassified	8.44
189	II	4	Mercury	Taurus	Unclassified	50.9
189	II	25	Jupiter	Gemini	Unclassified	65.26
189	III	12	Mercury	Taurus	End	52.44
189	III	22	Jupiter	Gemini	Unclassified	71.38
189	III	28	Mercury	Gemini	Unclassified	79.25
189	IV	26	Mercury	Leo	Unclassified	131.65
189	V	30	Mercury	Virgo	Unclassified	171.43
189	VI	8	Saturn	Aries	Unclassified	19.51
189	VI	25	Mercury	Virgo	Unclassified	157.66
189	VI_2	23	Mercury	Libra	Unclassified	186.23
189	VI_2	26	Jupiter	Gemini	End	89.33
189	VII	11	Mars	Cancer	Unclassified	100.04
189	VII	24	Venus	Scorpio	Unclassified	221.25
189	VIII	14	Mercury	Sagittarius	Unclassified	267.1
189	IX	2	Mercury	Capricorn	Unclassified	275.23
189	IX	5	Saturn	Aries	Unclassified	13.21
189	IX	12	Mercury	Sagittarius	Unclassified	263.62
189	IX	28	Venus	Aquarius	Beginning	301.26
189	X	5	Mars	Gemini	Unclassified	82.93
189	X	24	Jupiter	Gemini	Unclassified	79.34
189	X	26	Mercury	Aquarius	Unclassified	304.48
189	XI	27	Mercury	Aries	Unclassified	3
189	XII	19	Saturn	Aries	Unclassified	22.07
189	XII	26	Mercury	Taurus	Unclassified	30.92
194	III	19	Jupiter	Libra	Unclassified	202.28
194	IV	13	Saturn	Gemini	Unclassified	84.25
194	IV	23	Mercury	Cancer	Unclassified	108.7
194	X	3	Mercury	Capricorn	Unclassified	290.18
194	X	20	Mercury	Aquarius	Unclassified	302.57
194	XI	8	Mercury	Capricorn	Unclassified	288.31
194	XII	8	Mars	Pisces	End	354.77
194	XII	10	Saturn	Gemini	Unclassified	84.49
194	XII	15	Mars	Aquarius	End	324.71

Date (Seleucid Era)			Planet	Zodiacal Sign	Beginning / end	Babylonian longitude (°)
195	II	21[2]	Saturn	Cancer	Beginning	92.37
201	I	2	Mercury	Taurus	Unclassified	32.28
201	II	1	Saturn	Virgo	Unclassified	163.86
201	II	11	Mercury	Gemini	Unclassified	73.85
201	II	13	Jupiter	Gemini	Unclassified	69.73
201	III	12	Jupiter	Gemini	Unclassified	76.26
201	III	14	Mercury	Gemini	Unclassified	70.68
201	III	22	Mars	Cancer	Unclassified	118.01
201	IV	1	Mercury	Cancer	Unclassified	98.13
201	V	5	Mercury	Virgo	Unclassified	159.69
201	V	14	Saturn	Virgo	Unclassified	170.43
201	VI	24	Saturn	Virgo	Unclassified	175.21
201	VI	26	Mercury	Virgo	Unclassified	175.88
201	VII	8	Mars	Libra	Unclassified	186.55
201	VII	11	Jupiter	Cancer	Unclassified	93.83
201	IX	3	Venus	Sagittarius	Unclassified	259.59
201	IX	5	Venus	Sagittarius	Unclassified	258.17
201	IX	13	Mercury	Capricorn	Unclassified	282.22
201	X	4	Mercury	Aquarius	Beginning	293.9
201	X	14	Mercury	Capricorn	Unclassified	282.33
201	XI	2	Saturn	Libra	Beginning	182.19
201	XI	11	Jupiter	Gemini	Unclassified	83.85
201	XI	26	Mercury	Aquarius	Unclassified	318.55
208	X	19	Jupiter	Aquarius	Beginning	299.01
208	XII	4	Venus	Aries	Unclassified	3.76
212	II	14	Saturn	Capricorn	End	296.48
212	III	21	Mercury	Cancer	Unclassified	115.66
212	IV	19	Mercury	Cancer	Unclassified	104.43
234	IX	18	Mercury	Capricorn	Unclassified	282.64
234	X	8	Mercury	Aquarius	Beginning	291.26
234	XII	10	Saturn	Scorpio	Unclassified	223.41

Appendix E4: Beginning and end data from the Almanacs

Date (Seleucid Era)			Planet	Zodiacal Sign	Beginning / end	Babylonian longitude (°)
129	I	12	Mercury	Taurus	Unclassified	30.61
129	I	21	Venus	Taurus	Beginning	36.3
129	I	24	Jupiter	Taurus	Unclassified	40.73
129	II	21	Mercury	Gemini	Unclassified	66.27
129	II	27	Jupiter	Taurus	Unclassified	48.36
129	III	24	Mercury	Gemini	Unclassified	68.45
129	IV	9	Mercury	Gemini	End	92.42
129	V	11	Mercury	Leo	End	151.6
129	V	15	Saturn	Aries	Unclassified	4.72
129	VII	1	Jupiter	Gemini	Unclassified	66.33
129	XII_2	5	Saturn	Aries	Unclassified	7.51
129	XII_2	7	Mercury	Aries	Unclassified	14.36
179	IV	14	Venus	Cancer	Unclassified	112.64
179	V	10	Mercury	Leo	Unclassified	142.73
179	IX	5	Jupiter	Leo	End	147.48
179	IX	21	Saturn	Sagittarius	Unclassified	260.62

Date (Seleucid Era)			Planet	Zodiacal Sign	Beginning / end	Babylonian longitude (°)
179	X	16	Mercury	Aquarius	Unclassified	315.64
179	XI	11	Mercury	Pisces	Unclassified	331.27
179	XII	14	Mars	Aries	Unclassified	16.49
183	II	20	Mars	Capricorn	Unclassified	292.94
183	IV	7	Jupiter	Scorpio	Unclassified	229.62
183	VIII	29	Mercury	Sagittarius	Unclassified	260.74
183	IX	22	Jupiter	Sagittarius	Unclassified	253.66
183	IX	27	Mercury	Sagittarius	Unclassified	253.57
183	X	20	Saturn	Aquarius	Beginning	303.25
183	XI	29	Saturn	Aquarius	Unclassified	307.82
183	XII	10	Mercury	Pisces	Unclassified	349.5
190	IV	3	Saturn	Taurus	Unclassified	33.18
190	V	5	Venus	Libra	Beginning	183.83
198	VII	11	Mercury	Scorpio	Unclassified	228.64
198	IX	26	Mercury	Sagittarius	End	271.54
201	III	12	Jupiter	Gemini	Unclassified	76.26
201	III	22	Mars	Cancer	Unclassified	118.01
201	V	27	Mercury	Virgo	Unclassified	186.73
201	VI	24	Saturn	Virgo	Unclassified	175.21
201	VII	11	Jupiter	Cancer	Unclassified	93.83
201	VII	26	Mercury	Libra	End	209.46
201	IX	3	Venus	Sagittarius	Unclassified	259.59
201	IX	13	Mercury	Capricorn	Unclassified	282.22
201	X	4	Mercury	Aquarius	Beginning	293.9
201	X	14	Mercury	Capricorn	Unclassified	282.97
201	XI	2	Saturn	Libra	Beginning	182.19
201	XI	11	Jupiter	Gemini	Unclassified	83.85
209	II	19	Mercury	Taurus	Unclassified	47.09
209	III	5	Mercury	Gemini	Unclassified	73.49
209	III	29	Mercury	Leo	Unclassified[?]	121.26
209	V	3	Mercury	Virgo	Unclassified	164.91
209	IX	12	Mercury	Sagittarius	Unclassified	266.36
209	XI	2	Mercury	Aquarius	Beginning	299.41
209	XI	8	Mars	Pisces	Unclassified	336.79
209	XI	9	Jupiter	Aquarius	End	328.49
209	XII	4	Mercury	Pisces	End	357.24
209	XII	10	Jupiter	Pisces	Unclassified	335.68
234	III	8	Saturn	Libra	Unclassified	205.86
234	IV	1	Mercury	Gemini	End	89.33
234	IV	22	Jupiter	Aries	Unclassified	4.03
234	V	10	Mercury	Virgo	Unclassified	160.24
236	I	29	Jupiter	Taurus	Unclassified	52.2
236	II	6	Venus	Gemini	Unclassified	63.5
236	II	20	Jupiter	Taurus	End	56.78
236	III	15	Mercury	Cancer	Unclassified	107.93
236	IV	1	Saturn	Scorpio	Unclassified	228.26
236	IV	23	Mercury	Leo	End	155.6
236	V	21	Mercury	Leo	Unclassified	142.11
236	VI	12	Mercury	Virgo	Unclassified	168.21
236	VI	22	Jupiter	Gemini	Unclassified	74.6
236	VII	21	Saturn	Scorpio	Unclassified	234.86
236	VII	25	Mars	Cancer	Unclassified	95.39
236	VIII	8	Mercury	Sagittarius	Unclassified	253.69

Date (Seleucid Era)			Planet	Zodiacal Sign	Beginning / end	Babylonian longitude (°)
236	VIII	23	Mercury	Sagittarius	Unclassified	261.36
236	IX	7	Mercury	Sagittarius	Unclassified	247.09
236	X	16	Mars	Gemini	Unclassified	76.29
236	X	19	Jupiter	Gemini	Unclassified	64.56
236	X	23	Mercury	Capricorn	Unclassified	296.63
236	XI	6	Mercury	Aquarius	Unclassified	317.37
236	XI	6	Venus	Aquarius	Unclassified	323.22
236	XI	23	Mercury	Pisces	Unclassified	350.64
236	XII	27	Mercury	Aries	Unclassified	7.53
244	II	1	Jupiter	Capricorn	End	296.37
301	I	20	Mercury	Taurus	Unclassified	46.3
301	II	14	Saturn	Aquarius	Unclassified	304.41
301	II	20	Mercury	Taurus	End	51.2
301	III	I	Mercury	Gemini	Unclassified	67.58
301	VI	2	Mercury	Virgo	Unclassified	153.93
305	I	3	Saturn	Pisces	Unclassified	348.82
305	I	21	Mars	Virgo	Unclassified	161.18
305	II	5	Mercury	Gemini	Beginning	57.37
305	III	12	Mercury	Cancer	Unclassified	97.63
305	IV	16	Mercury	Cancer	Beginning	92.33
305	IV	22	Jupiter	Pisces	End	357.73
305	IV	29	Saturn	Pisces	End	355.02
305	V	2	Mercury	Cancer	Unclassified	118.77
305	VII	27	Mercury	Libra	Unclassified	194.89
305	VIII	5	Venus	Scorpio	Unclassified	228.83
305	VIII	13	Venus	Scorpio	Unclassified	224.1
305	VIII	19	Jupiter	Pisces	Unclassified	347.78
305	VIII	21	Saturn	Pisces	Unclassified	348.54
305	IX	3	Mercury	Scorpio	Unclassified	235.27
305	X	12	Mercury	Aquarius	Beginning	297.29
305	X	26	Mercury	Aquarius	Unclassified	315.34
305	XI	21	Mercury	Aquarius	Unclassified	301.64
305	XII	9	Saturn	Pisces	End	356.08
305	XII	25	Mercury	Pisces	Unclassified	334.72
305	XII_2	1	Jupiter	Aries	Unclassified	8.37
305	XII_2	28	Saturn	Aries	Unclassified	2.25
305	XII_2	29	Mercury	Taurus	Unclassified	41.28
372	I	4	Mercury	Taurus	Unclassified	33.46
372	II	12	Mercury	Gemini	Unclassified	72.59
372	II	26	Mars	Gemini	Unclassified	79.71
372	III	3	Saturn	Cancer	Unclassified	96.35
372	III	7	Jupiter	Libra	Unclassified	204.48
372	III	7	Mercury	Gemini	Unclassified	64.49
372	III	29	Mercury	Cancer	Beginning	91.3
372	IV	11	Saturn	Cancer	Unclassified	101.22
372	V	10	Mercury	Virgo	Unclassified	163.36
372	V	28	Mars	Leo	Unclassified	142.93
372	V	29	Mercury	Libra	Beginning	185.97
372	VI	25	Mercury	Virgo	Unclassified	176.76
372	VII	21	Jupiter	Scorpio	Unclassified	222.15
372	VII	28	Mercury	Libra	Unclassified	208.72
372	VIII	7	Saturn	Cancer	Unclassified	109.36
372	VIII	18	Jupiter	Scorpio	Unclassified	228.23

Date (Seleucid Era)			Planet	Zodiacal Sign	Beginning / end	Babylonian longitude (°)
372	IX	15	Mercury	Capricorn	Unclassified	282.91
372	IX	29	Venus	Capricorn	Unclassified	279.58
372	X	7	Mercury	Capricorn	Unclassified	291.04
372	X	19	Mercury	Capricorn	Unclassified	280.34
372	XII	4	Saturn	Cancer	Unclassified	102.59
372	XII	23	Jupiter	Sagittarius	Unclassified	245.99

Appendix F: a comparison of records in the Normal Star Almanacs with records in the Almanacs

Date (Seleucid Era)		Text		Record
92	[XII]	LBAT 1005	Rev. 3	The 21st, Venus' first appearance in the east in the beginning of Aries
		BM 40101+	Rev. 11	The 21st, Venus' first appearance[?] in the east in Aries
179	IV	LBAT 1043-44	Obv. 17	The 14th, Venus in the east […]
		LBAT 1136	Obv. 3	The 14th, Venus' first appearance in the east in Cancer
179	IV	LBAT 1043-44	Obv. 19	[…x+]1 (end of month) Saturn stationary in Sagittarius
		LBAT 1136	Obv. 4	(end of month) Saturn stationary in Sagittarius
179	V	LBAT 1043-44	Obv. 23	The 10th, Mercury in the east […]
		LBAT 1136	Obv. 6	The 10th, Mercury's last appearance in the east in Leo
189	III	LBAT **1055	Obv. 14-15	The 12th, Mercury's first appearance in the east in the end of Taurus
		LBAT 1141-42	Obv. 4	The 12th, Mercury's first appearance in the east in the end of Taurus
189	III	LBAT **1055	Obv. 15-16	The 22nd Jupiter's first appearance in Gemini
		LBAT 1141-42	Obv. 5	The 22nd Jupiter's first appearance in Gemini
189	V	LBAT **1055	Obv. 31	The 30th, Mercury's last appearance in the west in Virgo
		LBAT 1141-42	Obv. 10	The 30th, Mercury's last appearance in the west in Virgo
201	II	LBAT **1059	Obv. 10	The 11th, Mercury's last appearance in the west in Gemini
		LBAT 1151	Obv. 4	⌜The xth⌝ (7th-11th), Mercury in the west in Gemini […]
201	III	LBAT **1059	Obv. 15	The 12th, Jupiter's first appearance in Gemini
		LBAT 1151	Obv. 7	The 12th, Jupiter's first appearance in Gemini
201	III	LBAT **1059	Obv. 17	The 22nd, Mars' last appearance in Cancer
		LBAT 1151	Obv. 8	The 22nd, Mars' last appearance in Cancer
201	IV	LBAT **1059	Obv. 20	The 1st, Mercury's last appearance in the east in Cancer
		LBAT 1151	Obv. 9	The 1st, Mercury in the east […]
201	V	LBAT **1059	Obv. 30	The 27th, Mercury's last appearance in the west in Virgo
		LBAT 1151	Obv. 12	The 27th, Mercury's last appearance in the west in Virgo
201	VI	LBAT **1059	Obv. 33	The 24th, Saturn's first appearance in Virgo
		LBAT 1151	Obv. 13	The 24th, Saturn's first appearance in Virgo

Date (Seleucid Era)		Text		Record
201	VI	LBAT **1059	Obv. 33-34	The 26th, Mercury's first appearance in the east in Virgo
		LBAT 1151	Obv. 13	[…(end of month) Mercu]ry's ⌜first appearance⌝ in the east in Virgo
201	VII	LBAT **1059	Rev. 36	The 8th, Mars' first appearance in Libra
		LBAT 1151	Obv. 14	The 8th, Mars' ⌜first appearance in Leo?⌝ […]
201	VII	LBAT **1059	Rev. 37	The 11th, Jupiter stationary in Cancer
		LBAT 1151	Obv. 15	The 11th, Jupiter stationary in Cancer
201	VII	LBAT **1059	Rev. 37	The 26th, Mercury's last appearance in the east in the end of Libra
		LBAT 1151	Obv. 15	The 26th, Mercury's last appearance in the east in the end of Libra
201	IX	LBAT **1059	Rev. 48	The 3rd, Venus' last appearance in the west in Sagittarius
		LBAT 1151	Rev. 3	The 3rd, Venus' last appearance in the west in Sagittarius
201	IX	LBAT **1059	Rev. 48	The 5th, Venus' first appearance in the east in Sagittarius
		LBAT 1151	Rev. 3	The 6th, Venus in the east [first appearance…
201	IX	LBAT **1059	Rev. 49	The 11th, Jupiter's acronychal rising
		LBAT 1151	Rev. 4	The 11th, Jupiter's acronychal rising
201	IX	LBAT **1059	Rev. 50	The 13th, Mercury's first appearance in the west in Capricorn
		LBAT 1151	Rev. 4	The 13th, Mercury's first appearance in the west in Capricorn
201	X	LBAT **1059	Rev. 54	The 4th, Mercury's last appearance in the west in the beginning of Aquarius(?)
		LBAT 1151	Rev. 7	The 4th, Mercury's last appearance in the west in the beginning of ⌜x⌝ […]
201	X	LBAT **1059	Rev. 54	The 14th, Mercury's first appearance in the east in Capricorn(?)
		LBAT 1151	Rev. 7	The 14th, [Mercu]ry's first appearance in the east in Capricorn
201	XI	LBAT **1059	Rev. 60	The 2nd, Saturn stationary in the beginning of Libra
		LBAT 1151	Rev. 8	The 20th, Saturn in the beginning of Libra ⌜x⌝
201	XI	LBAT **1059	Rev. 60	The 11th, Jupiter stationary in Gemini
		LBAT 1151	Rev. 9	The 11th, Jupiter stationary in Gemini
201	XII	LBAT **1059	Rev. 70	The 29th, Mercury's first appearance in the west in Aries
		LBAT 1151	Rev. 12	The 29th, Mercury in the west in ⌜Aries? xx⌝
234	XII	BM 32247	Rev. 19	The 10th, Saturn stationary in Scorpio
		LBAT 1164-5	Rev. 10	The 10th, Saturn stationary in Scorpio

Appendix G: a comparison of records in the Goal-Year Texts with records in the non-mathematical predictive texts, to understand what "date corrections" are applied to the records when making predictions

Goal year (SE)	Text no.		Month	Observation
96	10	Obv.' 22	I	The 7th, Mercury's first appearance in the west in the beginning of Taurus
	LBAT **1007	Obv. 1	I	⌜The 14th⌝, Mercury in the west in the beginning of […]
96	10	Obv.' 8	I	Night of the 17th first part Venus 4 ½ cubits above γ Geminorum
	LBAT **1007	Obv. 3	I	Night of the 16th first part Venus[?] 4 [cubits] above γ Geminorum
96	10	'Rev. 3'-4'	I	Night of the 5th first part Mars, while moving back to the east, 2 ½ cubits below ε Leonis
	LBAT **1007	Obv. 4	I	⌜Night of the⌝ 21st first part Mars 3 cubits below[?] ε Leonis
96	10	Obv.' 23	I	Night of the 25th first part Mercury 1 cubit 4 fingers below β Tauri
	LBAT **1007	Obv. 4	I	Night of the 24th first [part] Mercury below β Tauri […]
96	10	Obv.' 24	I	[…] first part Mercury 1 5/6 cubits above ζ Tauri
	LBAT **1007	Obv. 5	I	Night of the 26th first part Mercury 1 1/3 cubits above ζ Tau(ri)
96	10	'Rev. 4'	I	Night of the 25th first part Mars 14 fingers above α Leonis
	LBAT **1007	Obv. 6	II	Night of the 11th first part Mars 14 fingers above α Leonis
96	10	Obv.' 25	II	The 13th, Mercury's last appearance in the west in the beginning of Gemini
	LBAT **1007	Obv. 6	II	The 13th, Mercury's last appearance in the west in Gemini
96	10	'Rev. 4'-5'	II	Night of the 9th first part Mars ½ cubit above ϱ Leonis
	LBAT **1007	Obv. 7	II	Night of the 25th first part Mars above ϱ [Leonis …]
96	10	Obv.' 9	III	The 3rd, Venus' last appearance in the west in Gemini
	LBAT **1007	Obv. 8	II	The 29th, Venus' ⌜last appearance[?]⌝ in the west in Gemini

Goal year (SE)	Text no.		Month	Observation
96	10	'Rev. 5'	II	Night of the 28th first part Mars 4 cubits below θ Leonis
	LBAT **1007	Obv. 9	III	Night of the 14th first part ⌜Mars⌝ 4 ⌜cubits⌝ below [θ] Leonis
96	10	'Rev. 6'	III	[…] first part Mars 1 finger above β Virginis, it came close
	LBAT **1007	Obv. 11	IV	x first part Mars 1 finger above β Virginis
96	10	Obv.' 11	IV	Night of the 10+[xth last part] Venus 1 ½ cubits […] μ Geminorum
	LBAT **1007	Obv. 12	IV	Night of the 11th last part Venus 1 ½ cubits below μ Geminorum
96	10	Obv.' 12	V	[…] last part of the night Venus 5 ½ cubits below α Geminorum
	LBAT 1008	Obv. 7	V	Night of the 1st last part Venus 5 ½ cubits below α Geminorum
96	10	'Rev. 7'	IV	Night of the 29th first part Mars 1 cubit above α Virginis
	LBAT **1007	Obv. 11	V	Night of the 15th first part Mars above α Virgin[is …]
96	10	'Rev. 7'-8'	V	Night of the 30th, 8 fingers [… α Lib]rae
	LBAT 1008	Obv. 14	VI	Night of the 16th first part Mars 8 fingers below α Librae
96	10	Obv.' 15	VI	Night of the 30th last part Venus 4 cubits below θ Leonis
	LBAT 1008	Obv. 15-16	VI	Night of the 29th last part Venus […] 4 cubits […]
96	10	Obv.' 18	IX	Night of the 4th last part Venus 2 fingers above β Scorpii
	LBAT 1008	Rev. 7	IX	Night of the 2nd last part Venus 2 ⌜fingers⌝ above β Scorpii
96	10	Obv.' 19	IX	[…] Venus 2 cubits above α Scorpii
	LBAT 1008	Rev. 8	IX	[…]°last part Venus⌝ 3 cubits above α Scorpii
96	10	Obv.' 19	IX	Night of the 21st last part Venus 1 cubit 4 fingers above θ Ophiuchi
	LBAT 1008	Rev. 9	IX	Night of the ⌜19th Venus⌝ 1 cubit 4 fingers above θ Ophiuchi

Goal year (SE)	Text no.		Month	Observation
96	10	Obv.' 20	X	[…] Venus 2 ½ cubits below β Capricorni; I watched, but I did not see β
	LBAT 1008	Rev. 15	X	Night of the ⌜23rd⌝ last part Venus 1 1/3 cubits below β Capricorni
105	14	'Obv. 4'	I	Night of the 19th first part Mars […] above η Geminorum
	LBAT *1011	Obv. 1	I	Night of the 5th first part Mars 20 fingers above η Geminorum
105	14	'Obv. 5'	I	[…] Mars 20 fingers above μ Geminorum
	LBAT *1011	Obv. 1	I	Night of the 9th first part Mars 20 fingers above μ Geminorum
105	14	'Obv. 5'	II	Night of the 1st first part Mars […] above γ Geminorum
	LBAT *1011	Obv. 2	I	Night of the 18th first part Mars 3 cubits above γ Geminorum
105	14	'Obv. 6'	II	[Night of the xth first] part Mars 3 ½ cubits below α Geminorum
	LBAT *1011	Obv. 4	II	[Night of the 1st] first part Mars 3 ½ cubits below α Geminorum
105	14	'Obv. 6'	II	Night of the 23rd first part Mars 2 ½ cubits below β Geminorum
	LBAT *1011	Obv. 5	II	Night of the 9th first part Mars below β Geminorum[…]
105	14	'Obv. 3'	III	The 23rd, Mars' last appearance in Cancer
	LBAT *1011	Obv. 6	II	The 23rd, Mars' last appearance in Cancer
106	15	Obv. 13	V	Night of the 10th last part Venus 3 fingers above α Leonis
	BM 41022+	Obv. 8	V	Night of the 8th last part Venus 3 fingers above α Leonis
106	15	Obv. 21	X	The 29th, Mercury's [first appearance …]
	BM 41022+	Rev. 15	X	29th, Mercury's [first appearance …]
106	15	Obv. 16	XII	[… Venus] 3 cubits [above α Tau]ri
	LBAT 1015	Rev. 6	XII	[…] first part Venus 3 cubits above α Tauri

Goal year (SE)	Text no.		Month	Observation
107	18	Rev.' 3	I	Night of the 17th first part Mars 2 [cubits] below α Gem
	LBAT 1016-18	Obv. 3	II	3rd first part Mars 3 ½ cubits below α Geminorum
107	16	'Obv.' 11'	II	Night of the 22nd first part Venus […] below δ Cancri
	LBAT 1016-18	Obv. 5-6	II	Night of the 19th first part Venus above [γ/δ] Cancri? […]
107	16	'Obv.' 21'	III	The 30th, [Mercury's] last appearance [in the west in] Cancer
	LBAT 1016-18	Obv. 13	III	The 29th, Mercury's last appearance in the west in Cancer
107	16	'Obv.' 12'-13'	IV	Night of the 7th first part Venus 5? cubits below θ Leonis
	LBAT 1016-18	Obv. 15	IV	⌜Night of the⌝ 6th first part Venus 4 cubits below θ Leonis
107	16	'Obv.' 21'	IV	The 24th, Mercury's [first appearance] in [the east in …]
	LBAT 1016-18	Obv. 16	IV	The 24th, ⌜Mercury's x first appearance?⌝
107	18	'Obv. 5'	IX	Around the 18th, Saturn's acronychal rising
	LBAT 1016-18	Rev. 3	X	The 13th, Saturn's acronychal rising
107	17	'Obv.' 1'	X	The 20th, Jupiter's acronychal rising
	LBAT 1016-18	Rev. 3	X	The 20th, Jupiter's acronychal rising
107	16	'Obv.' 17'-18'	XI	Night of the 11th [last part Venus] ½ cubit below β Capricorni
	LBAT 1016-18	Rev. 5	XI	Night of the 9th […]⌜x⌝ Venus 2 cubits below β [Cap]ricorni
107	16	'Obv.' 18'	XI	Night of the 25th last part Venus 1 cubit 8 fingers above γ Capricorni
	LBAT 1016-18	Rev. 6	XI	Night of the 22nd las[t part] Venus 1 cubit 8 fingers ⌜x⌝ […] γ Capricorni
107	16	'Obv.' 18'-19'	XI	Night of the 26th last part Venus 1 cubit 10 fingers above δ Capricorni
	LBAT 1016-18	Rev. 7	XI	Night of the 24th last part […] 1 cubit 8 fingers […] [δ Caprico]rni?

Goal year (SE)	Text no.		Month	Observation
107	18	'Obv. 7'-8'	XII	Night of the 26th first part Saturn 2 fingers above δ Cancri
	LBAT 1016-18	Rev. 11	XII	⌜x⌝ Saturn 2 fingers above δ Cancri
120	21	'Obv.' 6'	II	The 21st, Venus' [last appearance] in the west in Leo
	LBAT 1022	Obv. 7	II	The 17th Venus' last appearance in the west in Gemini
129	27	Obv. `7	I	The 11th, Mercury's first appearance in the west in Taurus?
	LBAT 1123	Obv. 1	I	The 12th, Mercury's first appearance in the west in Taurus
129	27	Obv. 19	III	The 26th?, Mercury's [first appearance] in the east …
	LBAT 1123	Obv. 6	III	The 24th, Mercury's first appearance in the east in Gemini
129	26	'Obv.' 3'	V	The 11th, Mercury's first appearance in the west in the end of Leo
	LBAT 1123	Obv. 9	V	The 11th, Mercury's first appearance in the west in the end of Leo
129	27	Obv. 21	[VII]	The 6th, Mercury's first appearance in the east in Virgo
	LBAT 1123	Obv. 12	[VII]	The 5th, Mercury ⌜xxx⌝ […]
129	27	Obv. 25	XII2	The 6th, Mer[cury's first appearance in the west in Aries]
	LBAT 1123	Rev. 4	XII2	The 7th, Mercury's first appearance in the west in Aries
129	27	Obv. 33	XI	The 20th?, Mars' acronychal rising
	LBAT 1123	Rev. 1	XI	The 14th, Mars' acronychal rising
135	31	Obv.' 11	IX	Night of the 3rd first part Venus 4 fingers above γ Capricorni
	LBAT 1026	Obv. 6	IX	[…γ] Capricorni 4 fingers
135	31	Obv.' 12	IX	Night of the 5th first part Venus 4 fingers above δ Capricorni
	LBAT 1026	Obv. 7	IX	[…]⌜Venus⌝ 4 fingers above δ Capricorni

Goal year (SE)	Text no.		Month	Observation
175	54	Obv.' 7	VI	Night of the 12th last part Jupiter, while moving back to the west, 4 cubits below α Arietis
	LBAT 1041-2	Obv. 15	VI	[…]⌜x⌝ Jupiter 4 ⌜x⌝ below α Arietis
175	54	Obv.' 13-14	VI	The 17th, Venus' [first appearance in the west in …] (ideal) first appearance on the 15th?
	LBAT 1041-2	Obv. 14	VI	The 11th, Venus' first appearance in Virgo
184	60	Obv.' 29	VIII	Night of the 27th last part Venus [..]. above θ Ophiuchi
	LBAT 1048	Obv. 7	VIII	Night of the 25th last part Venus above [θ Ophiuchi …]
184	60	Obv. 4	IX	Night […] 2 cubits [below] β Capricorni
	LBAT 1047	Line 9	VIII?	[… first] part? Jupiter 2 ½ cu[bits] below β Capricorni […]
184	60	Obv.' 2-3	IX	Around the 12th, Jupiter's last appearance in Capricorn
	LBAT 1047	Line 13	IX?	12th Jupiter's last appearance in Capricorn
187	63	Obv. 11	?	[…] Venus was 1 cubit 4 fingers below α Leonis
	LBAT 1049-50	Obv. 9	?	Night of the 2nd last part Venus 1 cubit 4 fingers below α Leonis
192	68	'Obv.' 9'	VI	Night of the 7th last part Venus 5 cubits below θ Leonis
	LBAT 1056	Obv. 5	VI	Night of the 5th last part Venus 5 cubits ⌜x⌝ θ [Leonis?]
192	68	'Obv.' 10'	VI	[Ni]ght of the 20+[xth last part] Venus 2/3? cubit below γ Virginis
	LBAT 1056	Obv. 9	VI	[…] last part Venus 1/3 cubit below γ ⌜Vir⌝ginis
192	68	'Obv.' 23'	VII	[… Saturn] 6 fingers above ζ Tauri
	LBAT 1056	Rev. 3	VII	[…] 21st last part Saturn 6 fingers above [ζ] Tauri?
192	68	'Obv.' 16'-17'	VII	The 29th, Mercury's first appearance in the east in the beginning of Scorpio […] ideal first appearance on the 27th?
	LBAT 1056	Rev. 4	VII	The 24th, Mercury in the east in Scor[pio …]

Goal year (SE)	Text no.		Month	Observation
192	68	'Obv.' 11'	VII	Night of the 29th last part Venus 2 ½ cubits below β Librae
	LBAT 1056	Rev. 5	VII	[Night] of the 27th last part Venus 2 ½ cubits below β Librae
192	68	'Obv.' 23'	VIII	The 11th, Saturn's acronychal rising
	LBAT 1056	Rev. 7	VIII	The 6th, Saturn's acronychal rising
192	68	'Obv.' 11'	VIII	Night of the 10th last part Venus 8 fingers above β Scorpii
	LBAT 1056	Rev. 7-8	VIII	Night of the 8th last part Venus ⌜above⌝ β [Scorpii? …]
194	69	Obv. 1	I	Around the 15th, Jupiter's acronychal [rising …]
	LBAT 1057	Obv. 2	I	The 16th, Jupiter's acronychal [rising …]
194	69	Obv. 21	II	Night of the 2nd first part Mercury 1 ½ cubits below β Tauri
	LBAT 1057	Obv. 5	II	Night of the 1st first part Mercury ⌜xxx⌝ below [β] Tauri
194	69	Obv. 8	II	Night of the 4th last part Venus 4 cubits below η Piscium
	LBAT 1057	Obv. 5-6	II	Night of the 2nd last part Venus 4 cubits below [η] Piscium
194	69	Obv. 9	II	Night of the 9th last part Venus 5 cubits below β Arietis
	LBAT 1057	Obv. 7	II	Night of the 8th last part Venus ⌜4?⌝ […] below β Arietis
194	69	Obv. 22	II	Night of the 9th first part Mercury 1 cubit 4 fingers above η Geminorum
	LBAT 1057	Obv. 8	II	Night of the 9th first part Mercury 1 ⌜cubit x⌝ fingers? above [η] Geminorum
194	69	Obv. 22	II	Night of the 11th first part Mercury 1 cubit 4 fingers above μ Geminorum
	LBAT 1057	Obv. 8	II	Night of the 11th first part Mercury 1 cubit 4 fingers? above μ Geminorum
194	69	Obv. 22-23	II	Night of the 13th last part Venus 6? [cubits] below α Arietis
	LBAT 1057	Obv. 8	II	Night of the 12th last part ⌜Venus⌝ 6 cubits below α Arietis

Goal year (SE)	Text no.		Month	Observation
194	69	Obv. 6	[II?]	Jupiter, while moving back to the east, was 3 cubits below β Librae
	LBAT 1057	Obv. 9-10	II	Night of the 13th first part Jupiter 3 cubits below β? Librae
194	69	Obv. 10	III	Night of the 10th last part Venus 2 cubits above α Tauri
	LBAT 1057	Obv. 13	III	Night of the 9th last part Venus 2 cubits above α Tauri
194	69	Obv. 10	III	Night of the 20th last part Venus 2 ½ cubits below β Tauri
	LBAT 1057	Obv. 13-14	III	Night of the 19th? last part Venus 2 ½ cubits below β Tauri
194	69	Obv. 1-2	[III?]	The 19th, Jupiter became stationary to the west, [nn] cubits behind β Librae, 3 cubits low to the south
	LBAT 1057	Obv. 14	III	The 19th, Jupiter stationary in Libra
194	69	Obv. 11	IV	Night of the 1st [last part Ve]nus 8 fingers above η Geminorum
	LBAT 1057	Obv. 15	III	Night of the 30th last part Venus 8 fingers above η Geminorum
194	69	Obv. 34	II	The 17th, Saturn's last appearance in Gemini
	LBAT 1057	Obv. 12	III	The 5th, Saturn ⌜xx⌝ […last appearance?]
194	69	LE 4	II	Night of the 20th first part Mars while moving back to the east 1 cubit below γ Virginis
	LBAT 1057	Obv. 13	III	[5th-9th… Mars] 1 cubit below γ Virginis
194	69	Le 4-5	III	Night of the 15th [first] part Mars 1 cubit above α Virginis
	LBAT 1057	Obv. 17	IV	Night of the 2nd first part Mars 2 cubits above α Virginis
194	69	Obv. 24	IV	The 7th, Mercury's first appearance in the east in Gemini … [(ideal) first appearance] on the 4th
	LBAT 1057	Obv. 18	IV	The 4th, Mercury's first appearance in the east ⌜xx⌝
194	69	Obv. 12	IV	Night of the 6th last part Venus 2? cubits above γ Geminorum
	LBAT 1057	Obv. 18	IV	Night of the 5th last part Venus 3 cubits above γ Geminorum

Goal year (SE)	Text no.		Month	Observation
194	69	Obv. 13	IV	Night of the 15th[?] [last part Venus] 4 cubits [below] α Geminorum
	LBAT 1057	Obv. 19	IV	Night of the 13th last part Venus 4 cubits below α Geminorum
194	69	Obv. 35	III	The 21st, Saturn's first appearance in Gemini
	LBAT 1057	Obv. 19	IV	The 13th, Saturn's first appearance in Gemini
194	69	Obv. 13	IV	Night of the 18th last part Venus 5 cubits below β Geminorum
	LBAT 1057	Obv. 20	IV	Night of the 17th[?] last part Venus 3 cubits below β Geminorum
194	69	Obv. 25	IV	The 23rd, Mercury's last appearance in the east in Cancer, I did not watch
	LBAT 1057	Obv. 21	IV	[…x+]3rd Mercury's last appearance in the east in Cancer
194	69	Rev. 2	VIII	Night of the 16th first part Mars 2 cubits below β Capricorni
	LBAT 1057	Rev. 2	IX	Night of the[?] 2nd first part Mars below β Capricorni […]
194	69	Obv. 28	X	The 5th, Mercury's first appearance in the west in Capricorn, ... (ideal) first appearance on the 4th
	LBAT 1057	Rev. 5	X	The 3rd, Mercury's first appearance in the west in Capricorn
194	69	LE 1	IX[?]	Around the 11th, Saturn's acronychal rising; I did not [watch]
	LBAT 1057	Rev. 5	X	The 6th, Saturn's acronychal rising
194	69	Obv. 7	IX	Night of the 24th last [part Jupiter] 1 cubit [above θ] Ophiuchi
	LBAT 1057	Rev. 6	X	Night of the 17th last part Jupiter ⌜x⌝ cubits above θ [Ophiuchi[?]]
194	69	Obv. 28-29	X	[…Mercury's last appearance in the west] in Aquarius: from the 20th, when I watched I did not see it
	LBAT 1057	Rev. 6	X	The 20th, Mercury in the west in Aquarius ⌜x⌝ […]
194	69	Obv. 29	XI	The 10th, Mercury's first appearance in the east in Capricorn, ... (ideal) first appearance on the 8th
	LBAT 1057	Rev. 8	XI	The 8th, Mercury's first appearance in the east in Capricorn

Goal year (SE)	Text no.		Month	Observation
194	69	Obv. 30	XI	Night of the 25th last part Mercury ½ cubit above γ Capricorni
	LBAT 1057	Rev. 8-9	XI	Night of the 24th last part Mercury ½ cubit above ⌜x⌝ […] Capricorni
194	69	Obv. 31	XI	Night of the 27th last part Mercury ½ cubit above δ Capricorni
	LBAT 1057	Rev. 9-10	XI	Night of the 26th last part Mercury above δ [Capricorni …]
194	69	Obv. 15	XI	Night of the xth first part Venus 2 ½ cubits below η Piscium
	LBAT 1057	Rev. 10	XI	Night of the 28th first part Venus 2 ½ cubits below η Piscium
194	69	Obv. 15-16	XII	[… Venus] 3 ½ cubits [below] β Arietis
	LBAT 1057	Rev. 12	XII	Night of the 5th first part Venus 3 ½ cubits below [β] Arietis
194	69	LE 3	XII	Around the 8th, Mars' last appearance in the end of Pisces
	LBAT 1057	Rev. 12	XII	The 8th, Mars' last appearance in the end of Pisces
194	69	Obv. 16	XII	Ni[ght of the xth first part] Venus 4 ½ cubits below α Arietis
	LBAT 1057	Rev. 13	XII	Night of the 9th first part Venus 4 ½ cubits below α Ari[etis]
194	69	LE 2	XI	Around the 11th, Saturn became stationary to the west 6 fingers in front of α Geminorum
	LBAT 1057	Rev. 13	XII	The 10th, Saturn stationary in Gemini
194	69	Obv. 31-32	XII	The 17th, Mercury's last appearance in the east in Pisces, from the 14th in the end of Aquarius, when I watched I did not see it
	LBAT 1057	Rev. 14	XII	[x+]5th Mercury's last appearance in the east in the end of Aquarius
194	69	Obv. 16	XII	Night of the 10+[xth first part Venus] 1? ½ cubits [below η Tau]ri
	LBAT 1057	Rev. 14	XII	[… x+]5th first part Venus 1 ½ cubits below η Tauri
194	69	Obv. 17	XII2	Night of the 14th? first part Venus […] below [β] Tauri
	LBAT 1057	Rev. 19	XII2	Night of the 15th first part Venus below [β] Tauri […]

Goal year (SE)	Text no.		Month	Observation
201	73	Obv. 31'	I	Night of the 9th first part Mercury 1 cubit above α Tauri
	LBAT **1059	Obv. 2-3	I	Night of the 8th first part Mercury 4 cubits above α Tauri
201	73	Rev. 36'	I	[…Mars] 4 cubits [above] γ Geminorum
	LBAT **1059	Obv. 3	I	Night of the 9th first part Mars 4 cubits above γ Geminorum
201	73	Obv. 32'	I	Night of the 17th[2] first part [Mercury …] below β Tauri
	LBAT **1059	Obv. 3-4	I	Night of the 16th first part Mercury 1 ½ cubits below β Tauri
201	73	Obv. 32'	I	[Night of the 1]9th first part Mercury 1 ½ cubits above ζ Tauri
	LBAT **1059	Obv. 4	I	Night of the 18th first part Mercury 1 ½ cubits above ζ Tauri
201	73	Obv. 33'	I	Night of the 10+[xth first part Mercury] 1 cubit 4 fingers [above η Geminorum]
	LBAT **1059	Obv. 5	I	Night of the 25th first part Mercury 1 cubit 4 fingers above η Geminorum
201	73	Obv. 34'	I	Night of the 28th first part Mercury […] above μ Ge[minorum]
	LBAT **1059	Obv. 5-6	I	Night of the 27th first part Mercury 1 cubit 4 fingers above μ Geminorum
201	73	Rev. 37'	I	[…] Mars 3 ½ cubits below α Geminorum
	LBAT **1059	Obv. 6	I	Night of the 28th first part Mars 3 ½ cubits below α Geminorum
201	73	Obv. 34'-35'	II	[Night of the xth first part Mercury] 4 cubits above γ Geminorum
	LBAT **1059	Obv. 8-9	II	Night of the 2nd first part Mercury 4 cubits above γ Geminorum
201	73	Rev. 37'	I	Night of the 21st first part Mars […]
	LBAT **1059	Obv. 10	II	Night of the 8th first part Mars 2 ½ cubits below β Geminorum
201	73	Rev. 38'	II	[…] Mars ½ cubit above δ Cancri
	LBAT **1059	Obv. 14	III	Night of the 2nd first part Mars ½ cubit above δ Cancri

Goal year (SE)	Text no.		Month	Observation
201	73	Obv. 1	III	The 13th, Jupiter's first appearance in Gemini
	LBAT **1059	Obv. 15	III	The 12th, Jupiter's first appearance in Gemini
201	73	Obv. 35'-36'	III	[The xth, Mercury's first appearance in the east in Gemini], ... (ideal) first appearance on the 14th
	LBAT **1059	Obv. 15	III	The 14th Mercury's first appearance in the west in Gemini
201	73	Rev. 17	IV	Night of the 12th first part Saturn while moving back to the west […] fingers [below γ Virginis]
	LBAT **1059	Obv. 16	III	Night of the 20th first part Saturn 6 fingers below γ Virginis
201	73	Obv. 37'	V	Around the 5th, Mercury's first appearance in the west in Vir[go?], I did not watch
	LBAT **1059	Obv. 26	V	The 5th, Mercury's first appearance in the west in Virgo
201	73	Rev. 17-18	V	The 27th, Saturn's last appearance in Virgo, from the 23rd, when I watched I did not see it
	LBAT **1059	Obv. 27	V	The 14th, Saturn's last appearance in Virgo
201	73	Obv. 37'	V	Around the 27th, [Mercury's last appearance in the west in …]
	LBAT **1059	Obv. 30	V	The 27th, Mercury's last appearance in the west in Virgo
201	73	Rev. 18-19	VII	[The xth, Saturn's] first appearance [in Virgo…behind Mercu]ry to the east; … (ideal) first appearance on the 12th
	LBAT **1059	Obv. 33	VI	The 24th, Saturn's first appearance in Virgo
201	73	Obv. 38'	VI	The 28th, Mercury's [first appearance] in the east in Virgo …
	LBAT **1059	Rev. 37	VI	The 26th, Mercury's first appearance in the east in Virgo
201	73	Obv. 38'	VII	[Night of the 6th?, last part Mercury] 2 cubits [above] α Virginis
	LBAT **1059	Rev. 36	VII	Night of the 7th last part Mercury 2 cubits above α Virginis
201	73	Rev. 39'	VII	[night of the xth] last part Mars 8 fingers below α Librae
	LBAT **1059	Rev. 42	VIII	Night of the 2nd last part Mars 8 fingers below α Librae

Goal year (SE)	Text no.		Month	Observation
201	73	Rev. 39'-40'	VII	Night of the 23rd last part Mars [below β Librae]
	LBAT **1059	Rev. 42	VIII	Night of the 9th last part Mars 3 ½ cubits below β Librae
201	73	Rev. 40'	VIII	[Night of the xth last part Mars] 8 fingers below β Scorpii
	LBAT **1059	Rev. 44-46	VIII	Night of the 29th last part of the night Mars 8 fingers below β Scorpii
201	73	Rev. 40'-41'	VIII	Night of the 23rd last part Mars […] above α Scorpii
	LBAT **1059	Rev. 48	IX	Night of the 9th last part Mars 2 ½ cubits above α Scorpii
201	73	Obv. 40'	IX	The 9th? Mercury's [first appearance] in the west in [Capricorn …]
	LBAT **1059	Rev. 50	IX	The 13th, Mercury's first appearance in the west in Capricorn
201	73	Rev. 41'	IX	[Night of the xth last part Mars] ½ cubit [above θ] Ophiuchi
	LBAT **1059	Rev. 50	IX	Night of the 25th last part Mars ½ cubit above θ Ophiuchi
201	73	Rev. 1-2	X	[The xth, Mercury's first appearance] in the east in Capricorn,... (ideal) first appearance on the 14th
	LBAT **1059	Rev. 54	X	The 14th, Mercury's first appearance in the east in Capricorn(?)
201	73	Rev. 19-20	IX	Around until the 7th? Saturn became stationary to the east … [behind α Virginis]
	LBAT **1059	Rev. 60	XI	The 2nd, Saturn stationary in the beginning of Libra
201	73	Rev. 41'	XI	Night of the 6th last part Mars 2 ½ cubits below β Capricorni
	LBAT **1059	Rev. 61	XI	Night of the 22nd last part Mars 2 ½ cubits below β Capricorni
201	73	Rev. 3	XI	The 28th, Mercury's last appearance in the east in Aquarius, from the 26th, when I watched I did not see it
	LBAT **1059	Rev. 61	XI	The 26th, Mercury's last appearance in the east in Capricorn
201	73	Rev. 42'	XII	[Night of the x]+1st last part Mars ½ cubit above δ Capricorni
	LBAT **1059	Rev. 68	XII	Night of the 17th last part Mars ½ cubit above δ Capricorni

Goal year (SE)	Text no.		Month	Observation
201	73	Rev. 4	I	The 1st, Mercury's first appearance in the west in Aries, ..., (ideal) first appearance on the 30th of Month XII
	LBAT **1059	Rev. 70	XII	The 29th, Mercury's first appearance in the west in Aries
201	73	Obv. 1	III	The 13th, Jupiter's first appearance in Gemini
	LBAT 1151	Obv. 7	III	The 12th, Jupiter's first appearance in Gemini
201	73	Rev. 18-19	VII	Saturn's first appearance [in Virgo]; (ideal) first appearance on the 12th
	LBAT 1151	Obv. 13	VI	The 24th, Saturn's first appearance in Virgo
201	73	Rev. 19	IX	Around until the 7th$^{?}$, when Saturn became stationary to the east …
	LBAT 1151	Rev. 4	IX	The 20th, ⌜Saturn⌝ […stationary$^{?}$]
201	73	Rev. 1-2	X	[Mercury's] (ideal) first appearance on the 14th
	LBAT 1151	Rev. 7	X	The 14th, [Mercu]ry's first appearance in the east in Capricorn
236	86	Obv. 27	II	Around the 4th, Saturn's acronychal rising
	LBAT 1174	Obv. 1	I	The 27th, Saturn's ⌜acronychal rising⌝
236	86	Obv. 12	II	Around the 11th, Venus' first appearance in the west in Gemini
	LBAT 1174	Obv. 3	II	The 6th, Venus' ⌜first appearance⌝ in the west in Gemini
236	86	Obv. 2	II$^{?}$	[Jupiter's] first appearance […] (ideal) first appearance on the 19th
	LBAT 1174	Obv. 4	II	The 20th, Jupiter's first appearance in the end of ⌜Taurus$^{?}$⌝
236	86	Obv. 20-21	II	Around the 20th, Mercury's last appearance in the east, omitted
	LBAT 1174	Obv. 4	II	The 20th, Mercury's last appearance in the east, omitted
236	86	Obv. 21	III	The 19th, Mercury's first appearance in the west in Cancer … (ideal) first appearance on the 17th
	LBAT 1174	Obv. 5	III	The 15th, Mercury's first appearance in the west in Cancer

Goal year (SE)	Text no.		Month	Observation
236	86	Obv. 27	IV	Until the 8th, when Saturn became stationary to the west…
	LBAT 1174	Obv. 7	IV	The 1st, Saturn stationary in Scorpio
236	86	Obv. 22	IV	Around the 23rd, Mercury's last appearance in the west in Leo
	LBAT 1174	Obv. 8-9	IV	The 23rd, Mercury's last appearance in the west in the end of Leo
236	86	Obv. 22	V	The 24th, Mercury's first appearance in the east in Leo … (ideal) first appearance on the 21st
	LBAT 1174	Obv. 10	V	The 21st, Mercury's first appearance in the east in Leo
236	86	Obv. 23	VI	[last] appearance of Mercury in Virgo, when I watched from the 12th I did not see it
	LBAT 1174	Obv. 11-12	VI	The 12th, Mercury's last appearance in the east in Virgo
236	86	Obv. 23	VIII	Around the 8th, Mercury's first appearance in the west in Sagittarius, I did not watch
	LBAT 1174	Rev. 1	VIII	The 8th, Mercury's first appearance in the east in Sagittarius
236	86	Obv. 28	VIII	The 4th, Saturn's last appearance in Scorpio, from the 2nd when I watched I did not see it
	LBAT 1174	Obv. 13	VII	The 21st, Saturn's last appearance in Scorpio
236	86	Obv. 23-24	VIII	Around the 23rd, Mercury's last appearance in the west in Sagittarius, I did not watch
	LBAT 1174	Rev. 2	VIII	The 23rd, Mercury's last appearance in the west in Sagittarius
236	86	Obv. 38	[IX]	Around the 2nd, Mars' acronychal rising
	LBAT 1174	Rev. 3	IX	The 6th, ⌜Mars' acronychal rising⌝
236	86	Obv. 24	IX	Around the 7th, Mercury's first appearance in the east in Sagittarius, I did not watch
	LBAT 1174	Rev. 3	IX	The 7th, Mercury's first appearance in the east in Sagittarius
236	86	Obv. 24	X	Around the 13th, Mercury's last appearance in the east in Capricorn, I did not watch
	LBAT 1174	Rev. 6	X	The 23rd, Mercury's last appearance in the east in Capricorn

Goal year (SE)	Text no.		Month	Observation
236	86	Obv. 18	XI	Around the 10th, Venus' last appearance in the west in the end of Aquarius
	LBAT 1174	Rev. 7	XI	The 6th, Venus' last appearance in the west in Aquarius
236	86	Obv. 19	XI	The 15th, Venus' first appearance in the east in Aquarius
	LBAT 1174	Rev. 7	XI	The 8th, Venus' first appearance in the east in Aquarius
245	88	'Obv. 18'-19'	I	Around until the 10th, Mars became stationary to the east
	LBAT **1179-80	Obv. 2	I	[2]7th Mars ⌜stationary⌝ in Sagittarius
245	88	'Obv. 19'	II	Around the 20th, Mars' acronychal rising.
	LBAT **1179-80	Obv. 4	II	The 29th, Mars' acronychal rising.
245	88	'Obv. 8'	III	The 29th, Mercury's last appearance in the west in …
	LBAT *1179-80	Obv. 5-6	III	The 22nd, Mercury's last appearance [in x in] Cancer
245	88	'Obv. 19'-20'	III	Until the 25th, Mars became stationary to the west
	LBAT **1179-80	Obv. 7	IV	The 3rd, Mars stationary in the beginning of Sagittarius
245	88	'Obv. 16'	IV	Around until the 14th, Saturn became stationary to the east in Pisces
	LBAT *1079-80	Obv. 7	IV	The 7th, Saturn ⌜stationary⌝ [in] P[isce]s
245	88	'Obv. 9'	IV	(ideal) first appearance in the east on the 22nd
	LBAT *1179-80	Obv. 8	IV	The 22nd, Mercury's first appearance in the east in Cancer
245	88	'Obv. 10'-11'	VII	Around the 18th, [Mercury's last appearance] in the west … [omitted]
	LBAT *1179-80	Obv. 13-14	VII	The 15th, Mercury's last appearance in the west, omitted
245	88	'Obv. 11'	VIII	The 8th, Mercury's [first appearance] in the east in … (ideal) first appearance on the 5th
	LBAT *1179-80	Rev. 15-16	VIII	⌜The 8th⌝ [Mercu]ry's first appearance in the east in the end of Libra

Goal year (SE)	Text no.		Month	Observation
246	91	Obv.' 2	I[?]	Around the 6th, Jupiter's first appearance in the end of Pisces
	LBAT *1181	Obv. 1	I	The 4th, Jupiter's first appearance in Pisces
247	92	Obv. 11	I	The 4th, Mer[cury's] first appearance […] (ideal) first appearance on the 3rd[?]
	LBAT 1182	Obv. 1	I	The 2nd, ⌜Mercury's[?]⌝ first appearance in the west in Taurus
247	92	Obv. 14	IV	[The x]+1st, Mercury's last appearance in the east in the beginning of Gemini; from the 28th of Month III when I watched [I did not see it…]
	LBAT 1182	Obv. 6	III	⌜The 25th⌝, Mercury's last appearance in the east in Gemini

Appendix H: an illustration of whether a month shift is necessary or not when using Goal-Year periods to make planetary predictions, for each month of the Metonic cycle

Month in observations year										
Jupiter (71)	Jupiter (83)	Venus (8)	Mercury (46)	Saturn (59)	Mars (79)	Mars (47)	Moon (18)		Goal year month	Metonic cycle year
I	**XII**	**XII_2**	**XII_2**	**XII_2**	I	I	**XII**	… predicts …	I	1
II	**I**	**I**	**I**	**I**	II	II	**I**		II	
III	**II**	**II**	**II**	**II**	III	III	**II**		III	
IV	**III**	**III**	**III**	**III**	IV	IV	**III**		IV	
V	**IV**	**IV**	**IV**	**IV**	V	V	**IV**		V	
VI	**V**	**V**	**V**	**V**	VI	VI	**V**		VI	
VII	**VI**	**VI**	**VI**	**VI**	**VII**	**VII**	**VI**		VI_2	
VIII	VII	VII	VII	VII	**VIII**	**VIII**	VII		VII	
IX	VIII	VIII	VIII	VIII	**IX**	**IX**	VIII		VIII	
X	IX	IX	IX	IX	**X**	**X**	IX		IX	
XI	X	X	X	X	**XI**	**XI**	X		X	
XII	XI	XI	XI	XI	**XII**	**XII**	XI		XI	
XII_2	XII	XII	XII	XII	**XII_2**	**XII_2**	XII		XII	
I	I	I	I	I	I	I	I	… predicts …	I	2
II	II	II	II	II	II	II	II		II	
III	III	III	III	III	III	III	III		III	
IV	IV	IV	IV	IV	IV	IV	IV		IV	
V	V	V	V	V	V	V	V		V	
VI	VI	VI	VI	VI	VI	VI	VI		VI	
VII	VII	VII	VII	VII	VII	VII	VII		VII	

Month in observations year										
Jupiter (71)	Jupiter (83)	Venus (8)	Mercury (46)	Saturn (59)	Mars (79)	Mars (47)	Moon (18)		Goal year month	Metonic cycle year
VIII	VIII	VIII	VIII	VIII	VIII	VIII	VIII		VIII	
IX	IX	IX	IX	IX	IX	IX	IX		IX	
X	X	X	X	X	X	X	X		X	
XI	XI	XI	XI	XI	XI	XI	XI		XI	
XII	XII	XII	XII	XII	XII	XII	XII		XII	
I	**XII_2**	I	I	I	I	I	**XII_2**	…	I	3
II	**I**	II	II	II	II	II	**I**	predicts …	II	
III	**II**	III	III	III	III	III	**II**		III	
IV	**III**	IV	IV	IV	IV	IV	**III**		IV	
V	**IV**	V	V	V	V	V	**IV**		V	
VI	**V**	VI	VI	VI	VI	VI	**V**		VI	
VII	**VI**	VII	VII	**VI_2**	VII	VII	**VI**		VII	
VIII	**VII**	VIII	VIII	**VII**	VIII	VIII	**VII**		VIII	
IX	**VIII**	IX	IX	**VIII**	IX	IX	**VIII**		IX	
X	**IX**	X	X	**IX**	X	X	**IX**		X	
XI	**X**	XI	XI	**X**	XI	XI	**X**		XI	
XII	**XI**	XII	XII	**XI**	XII	XII	**XI**		XII	
I	**XII**	XII_2	XII_2	**XII**	**I**	**I**	**XII**		XII_2	
II	I	I	I	I	**II**	**II**	I	…	I	4
III	II	II	II	II	**III**	**III**	II	predicts …	II	
IV	III	III	III	III	**IV**	**IV**	III		III	
V	IV	IV	IV	IV	**V**	**V**	IV		IV	

Month in observations year										
Jupiter (71)	Jupiter (83)	Venus (8)	Mercury (46)	Saturn (59)	Mars (79)	Mars (47)	Moon (18)		Goal year month	Metonic cycle year
VI	V	V	V	V	**VI**	**VI**	V		V	
VII	VI	VI	VI	VI	**VI_2**	**VII**	VI		VI	
VIII	VII	VII	VII	VII	VII	**VIII**	VII		VII	
IX	VIII	VIII	VIII	VIII	VIII	**IX**	VIII		VIII	
X	IX	IX	IX	IX	IX	**X**	IX		IX	
XI	X	X	X	X	X	**XI**	X		X	
XII	XI	XI	XI	XI	XI	**XII**	XI		XI	
XII_2	XII	XII	XII	XII	XII	**XII_2**	XII		XII	
I	I	I	I	I	I	I	I	…	I	5
II	II	II	II	II	II	II	II	predicts …	II	
III	III	III	III	III	III	III	III		III	
IV	IV	IV	IV	IV	IV	IV	IV		IV	
V	V	V	V	V	V	V	V		V	
VI	VI	VI	VI	VI	VI	VI	VI		VI	
VII	VII	VII	VII	VII	VII	VII	VII		VII	
VIII	VIII	VIII	VIII	VIII	VIII	VIII	VIII		VIII	
IX	IX	IX	IX	IX	IX	IX	IX		IX	
X	X	X	X	X	X	X	X		X	
XI	XI	XI	XI	XI	XI	XI	XI		XI	
XII	XII	XII	XII	XII	XII	XII	XII		XII	
I	**XII_2**	I	I	**XII_2**	I	I	**XII_2**	…	I	6
II	**I**	II	II	**I**	II	II	**I**	predicts	II	

Month in observations year										
Jupiter (71)	Jupiter (83)	Venus (8)	Mercury (46)	Saturn (59)	Mars (79)	Mars (47)	Moon (18)		Goal year month	Metonic cycle year
								…		
III	**II**	III	III	**II**	III	III	**II**		III	
IV	**III**	IV	IV	**III**	IV	IV	**III**		IV	
V	**IV**	V	V	**IV**	V	V	**IV**		V	
VI	**V**	VI	VI	**V**	VI	VI	**V**		VI	
VII	**VI**	VII	VII	**VI**	VII	VII	**VI**		VII	
VIII	**VII**	VIII	VIII	**VII**	VIII	VIII	**VII**		VIII	
IX	**VIII**	IX	IX	**VIII**	IX	IX	**VIII**		IX	
X	**IX**	X	X	**IX**	X	X	**IX**		X	
XI	**X**	XI	XI	**X**	XI	XI	**X**		XI	
XII	**XI**	XII	XII	**XI**	XII	XII	**XI**		XII	
XII_2	**XII**	XII_2	XII_2	**XII**	XII_2	**I**	**XII**		XII_2	
I	I	I	I	I	I	**II**	I	…	I	7
II	II	II	II	II	II	**III**	II	predicts …	II	
III	III	III	III	III	III	**IV**	III		III	
IV	IV	IV	IV	IV	IV	**V**	IV		IV	
V	V	V	V	V	V	**VI**	V		V	
VI	VI	VI	VI	VI	VI	**VII**	VI		VI	
VII	VII	VII	VII	VII	VII	**VIII**	VII		VII	
VIII	VIII	VIII	VIII	VIII	VIII	**IX**	VIII		VIII	
IX	IX	IX	IX	IX	IX	**X**	IX		IX	
X	X	X	X	X	X	**XI**	X		X	
XI	XI	XI	XI	XI	XI	**XII**	XI		XI	
XII	XII	XII	XII	XII	XII	**XII_2**	XII		XII	

Month in observations year										
Jupiter (71)	Jupiter (83)	Venus (8)	Mercury (46)	Saturn (59)	Mars (79)	Mars (47)	Moon (18)		Goal year month	Metonic cycle year
I	I	I	I	I	I	I	I	…	I	8
II	II	II	II	II	II	II	II	predicts …	II	
III	III	III	III	III	III	III	III		III	
IV	IV	IV	IV	IV	IV	IV	IV		IV	
V	V	V	V	V	V	V	V		V	
VI	VI	VI	VI	VI	VI	VI	VI		VI	
VII	**VI_2**	VII	VII	VII	VII	VII	VII		VII	
VIII	**VII**	VIII	VIII	VIII	VIII	VIII	VIII		VIII	
IX	**VIII**	IX	IX	IX	IX	IX	IX		IX	
X	**IX**	X	X	X	X	X	X		X	
XI	**X**	XI	XI	XI	XI	XI	XI		XI	
XII	**XI**	XII	XII	XII	XII	XII	XII		XII	
I	**XII**	I	I	**XII_2**	I	I	**XII_2**	…	I	9
II	**I**	II	II	**I**	II	II	**I**	predicts …	II	
III	**II**	III	III	**II**	III	III	**II**		III	
IV	**III**	IV	IV	**III**	IV	IV	**III**		IV	
V	**IV**	V	V	**IV**	V	V	**IV**		V	
VI	**V**	VI	VI	**V**	VI	VI	**V**		VI	
VII	**VI**	**VI_2**	**VI_2**	**VI**	VII	VII	**VI**		VII	
VIII	**VII**	**VII**	**VII**	**VII**	VIII	VIII	**VII**		VIII	
IX	**VIII**	**VIII**	**VIII**	**VIII**	IX	IX	**VIII**		IX	
X	**IX**	**IX**	**IX**	**IX**	X	X	**IX**		X	

Month in observations year										
Jupiter (71)	Jupiter (83)	Venus (8)	Mercury (46)	Saturn (59)	Mars (79)	Mars (47)	Moon (18)		Goal year month	Metonic cycle year
XI	**X**	**X**	**X**	**X**	XI	XI	**X**		XI	
XII	**XI**	**XI**	**XI**	**XI**	XII	XII	**XI**		XII	
XII_2	**XII**	**XII**	**XII**	**XII**	XII_2	**I**	**XII**		XII_2	
I	I	I	I	I	I	**II**	I	…	I	10
II	II	II	II	II	II	**III**	II	predicts …	II	
III	III	III	III	III	III	**IV**	III		III	
IV	IV	IV	IV	IV	IV	**V**	IV		IV	
V	V	V	V	V	V	**VI**	V		V	
VI	VI	VI	VI	VI	VI	**VI_2**	VI		VI	
VII	VII	VII	VII	VII	VII	VII	VII		VII	
VIII	VIII	VIII	VIII	VIII	VIII	VIII	VIII		VIII	
IX	IX	IX	IX	IX	IX	IX	IX		IX	
X	X	X	X	X	X	X	X		X	
XI	XI	XI	XI	XI	XI	XI	XI		XI	
XII	XII	XII	XII	XII	XII	XII	XII		XII	
I	**XII_2**	I	I	I	I	I	**XII_2**	…	I	11
II	**I**	II	II	II	II	II	**I**	predicts …	II	
III	**II**	III	III	III	III	III	**II**		III	
IV	**III**	IV	IV	IV	IV	IV	**III**		IV	
V	**IV**	V	V	V	V	V	**IV**		V	
VI	**V**	VI	VI	VI	VI	VI	**V**		VI	
VII	**VI**	VII	VII	VII	VII	VII	**VI**		VII	

Month in observations year										
Jupiter (71)	Jupiter (83)	Venus (8)	Mercury (46)	Saturn (59)	Mars (79)	Mars (47)	Moon (18)		Goal year month	Metonic cycle year
VIII	**VII**	VIII	VIII	VIII	VIII	VIII	**VII**		VIII	
IX	**VIII**	IX	IX	IX	IX	IX	**VIII**		IX	
X	**IX**	X	X	X	X	X	**IX**		X	
XI	**X**	XI	XI	XI	XI	XI	**X**		XI	
XII	**XI**	XII	XII	XII	XII	XII	**XI**		XII	
I	**XII**	XII_2	XII_2	XII_2	**I**	**I**	**XII**		XII_2	
II	I	I	I	I	**II**	**II**	I	…	I	12
III	II	II	II	II	**III**	**III**	II	predicts …	II	
IV	III	III	III	III	**IV**	**IV**	III		III	
V	IV	IV	IV	IV	**V**	**V**	IV		IV	
VI	V	V	V	V	**VI**	**VI**	V		V	
VII	VI	VI	VI	VI	**VII**	**VII**	VI		VI	
VIII	VII	VII	VII	VII	**VIII**	**VIII**	VII		VII	
IX	VIII	VIII	VIII	VIII	**IX**	**IX**	VIII		VIII	
X	IX	IX	IX	IX	**X**	**X**	IX		IX	
XI	X	X	X	X	**XI**	**XI**	X		X	
XII	XI	XI	XI	XI	**XII**	**XII**	XI		XI	
XII_2	XII	XII	XII	XII	**XII_2**	**XII_2**	XII		XII	
I	I	I	I	I	I	I	I	…	I	13
II	II	II	II	II	II	II	II	predicts …	II	
III	III	III	III	III	III	III	III		III	
IV	IV	IV	IV	IV	IV	IV	IV		IV	

Month in observations year										Metonic cycle year
Jupiter (71)	Jupiter (83)	Venus (8)	Mercury (46)	Saturn (59)	Mars (79)	Mars (47)	Moon (18)		Goal year month	
V	V	V	V	V	V	V	V		V	
VI	VI	VI	VI	VI	VI	VI	VI		VI	
VII	VII	VII	VII	VII	VII	VII	VII		VII	
VIII	VIII	VIII	VIII	VIII	VIII	VIII	VIII		VIII	
IX	IX	IX	IX	IX	IX	IX	IX		IX	
X	X	X	X	X	X	X	X		X	
XI	XI	XI	XI	XI	XI	XI	XI		XI	
XII	XII	XII	XII	XII	XII	XII	XII		XII	
I	**XII_2**	I	I	**XII_2**	I	I	**XII_2**	… predicts …	I	14
II	**I**	II	II	**I**	II	II	**I**		II	
III	**II**	III	III	**II**	III	III	**II**		III	
IV	**III**	IV	IV	**III**	IV	IV	**III**		IV	
V	**IV**	V	V	**IV**	V	V	**IV**		V	
VI	**V**	VI	VI	**V**	VI	VI	**V**		VI	
VII	**VI**	VII	VII	**VI**	VII	VII	**VI**		VII	
VIII	**VII**	VIII	VIII	**VII**	VIII	VIII	**VII**		VIII	
IX	**VIII**	IX	IX	**VIII**	IX	IX	**VIII**		IX	
X	**IX**	X	X	**IX**	X	X	**IX**		X	
XI	**X**	XI	XI	**X**	XI	XI	**X**		XI	
XII	**XI**	XII	XII	**XI**	XII	XII	**XI**		XII	
I	**XII**	XII_2	XII_2	**XII**	XII_2	**I**	**XII**		XII_2	
II	I	I	I	I	I	**II**	I	…	I	15

Month in observations year										
Jupiter (71)	Jupiter (83)	Venus (8)	Mercury (46)	Saturn (59)	Mars (79)	Mars (47)	Moon (18)		Goal year month	Metonic cycle year
III	II	II	II	II	II	**III**	II	predicts …	II	
IV	III	III	III	III	III	**IV**	III		III	
V	IV	IV	IV	IV	IV	**V**	IV		IV	
VI	V	V	V	V	V	**VI**	V		V	
VI_2	VI	VI	VI	VI	VI	**VII**	VI		VI	
VII	VII	VII	VII	VII	VII	**VIII**	VII		VII	
VIII	VIII	VIII	VIII	VIII	VIII	**IX**	VIII		VIII	
IX	IX	IX	IX	IX	IX	**X**	IX		IX	
X	X	X	X	X	X	**XI**	X		X	
XI	XI	XI	XI	XI	XI	**XII**	XI		XI	
XII	XII	XII	XII	XII	XII	**XII_2**	XII		XII	
I	I	I	I	I	I	I	I	…	I	16
II	II	II	II	II	II	II	II	predicts …	II	
III	III	III	III	III	III	III	III		III	
IV	IV	IV	IV	IV	IV	IV	IV		IV	
V	V	V	V	V	V	V	V		V	
VI	VI	VI	VI	VI	VI	VI	VI		VI	
VII	VII	VII	VII	VII	VII	VII	VII		VII	
VIII	VIII	VIII	VIII	VIII	VIII	VIII	VIII		VIII	
IX	IX	IX	IX	IX	IX	IX	IX		IX	
X	X	X	X	X	X	X	X		X	
XI	XI	XI	XI	XI	XI	XI	XI		XI	
XII	XII	XII	XII	XII	XII	XII	XII		XII	

Month in observations year										
Jupiter (71)	Jupiter (83)	Venus (8)	Mercury (46)	Saturn (59)	Mars (79)	Mars (47)	Moon (18)		Goal year month	Metonic cycle year
I	**XII₂**	I	I	**XII₂**	I	I	**XII₂**	… predicts …	I	17
II	**I**	II	II	**I**	II	II	**I**		II	
III	**II**	III	III	**II**	III	III	**II**		III	
IV	**III**	IV	IV	**III**	IV	IV	**III**		IV	
V	**IV**	V	V	**IV**	V	V	**IV**		V	
VI	**V**	VI	VI	**V**	VI	VI	**V**		VI	
VII	**VI**	VII	VII	**VI**	VII	VII	**VI**		VII	
VIII	**VII**	VIII	VIII	**VII**	VIII	VIII	**VII**		VIII	
IX	**VIII**	IX	IX	**VIII**	IX	IX	**VIII**		IX	
X	**IX**	X	X	**IX**	X	X	**IX**		X	
XI	**X**	XI	XI	**X**	XI	XI	**X**		XI	
XII	**XI**	XII	XII	**XI**	XII	XII	**XI**		XII	
XII₂	**XII**	XII₂	XII₂	**XII**	XII₂	**I**	**XII**		XII₂	
I	I	I	I	I	I	**II**	I	… predicts …	I	18
II	II	II	II	II	II	**III**	II		II	
III	III	III	III	III	III	**IV**	III		III	
IV	IV	IV	IV	IV	IV	**V**	IV		IV	
V	V	V	V	V	V	**VI**	V		V	
VI	VI	VI	VI	VI	VI	**VII**	VI		VI	
VII	VII	VII	VII	VII	VII	**VIII**	VII		VII	
VIII	VIII	VIII	VIII	VIII	VIII	**IX**	VIII		VIII	
IX	IX	IX	IX	IX	IX	**X**	IX		IX	

Month in observations year										
Jupiter (71)	Jupiter (83)	Venus (8)	Mercury (46)	Saturn (59)	Mars (79)	Mars (47)	Moon (18)		Goal year month	Metonic cycle year
X	X	X	X	X	X	**XI**	X		X	
XI	XI	XI	XI	XI	XI	**XII**	XI		XI	
XII	XII	XII	XII	XII	XII	**XII_2**	XII		XII	
I	**XII_2**	I	I	I	I	I	I	…	I	19
II	**I**	II	II	II	II	II	II	predicts …	II	
III	**II**	III	III	III	III	III	III		III	
IV	**III**	IV	IV	IV	IV	IV	IV		IV	
V	**IV**	V	V	V	V	V	V		V	
VI	**V**	VI	VI	VI	VI	VI	VI		VI	
VII	**VI**	VII	VII	VII	VII	VII	**VI_2**		VII	
VIII	**VII**	VIII	VIII	VIII	VIII	VIII	**VII**		VIII	
IX	**VIII**	IX	IX	IX	IX	IX	**VIII**		IX	
X	**IX**	X	X	X	X	X	**IX**		X	
XI	**X**	XI	XI	XI	XI	XI	**X**		XI	
XII	**XI**	XII	XII	XII	XII	XII	**XI**		XII	

Appendix I: a comparison of records in the Goal-Year Texts with records in the non-mathematical predictive texts, to determine when a "month shift" is applied to the date of records when making predictions

	Year (SE)	Text				Month shift- Seen?	Expected?
Jupiter's Greek-letter phenomena							
Diary	34	-277 A	Rev. 19	**VI**	The 20th, Jupiter became stationary in Gemini		
NSA	105	BM 132283	Obv. 20	**V**	The 20th, Jupiter in the end of Taurus […]	y	y
GYT	36	17	'Obv.' 1'	**X**	The 20th, Jupiter's acronychal rising		
NSA	107	LBAT 1016-18	Rev. 3	**[X?]**	The 20th, Jupiter's acronychal rising	n	n
Diary	58	-253 A1	Obv.' 1	**[VII]**	The 1st, Jupiter became stationary in Gemini		
Alm	129	LBAT 1123	Obv. 12	**[VII]**	The 1st, Jupiter stationary in Gemini	n	n
GYT	58	27	Obv. 3	**[XI]**	Around the 4th, when Jupiter became stationary to the west…		
Alm	129	LBAT 1123	Rev. 1	**XI**	[1st-12th Jup]iter stationary in Taurus	n	n
Diary	66	-245 B	Rev.' 3	**IV**	The 8th, Jupiter's acronychal rising		
NSA	137	LBAT 1027-8	Obv. 5	**[IV?]**	[8th-13th] Jupiter's acronychal rising	n	n
Diary	79	-232	Obv. 5	**VII**	Around the 14th Jupiter became stationary to the west in the e[nd of Aquarius]		
NSA	150	LBAT *1030	Rev. 1	**VII**	The 14th, Jupiter stationary in the end of Aquarius	n	n
Diary	79	-232	Rev. 24	**XI**	Around the 27th, Jupiter's last appearance in Pisces		
NSA	150	LBAT *1030	Rev. 18	**XI**	The 24th/29th, first part Jupiter in the west [in x last appearance]	n	n
Diary	114	-197 C1	Rev.' 3-4	**X**	The 28th, Jupiter's last appearance in Aquarius		
Alm	185	LBAT 1139	Obv. 7	**[X]**	⌜x⌝ Jupiter in Aquarius ⌜x⌝	n	n

	Year (SE)	Text				Month shift- Seen[?]	Expected[?]
Diary	118	-193 A	'Rev. 3'	**II**	25th, Jupiter's last appearance in Gemini		
NSA	189	LBAT **1055	Obv. 12	**II**	The 25th, Jupiter's last appearance in Gemini	n	n
Diary	118	-193 B	'Obv.' 10'	**VII**	Around the 26th, when Jupiter became stationary to the west […]		
NSA	189	LBAT **1055	Rev. 44	**VI_2**	The 26th, Jupiter stationary in the end of Gemini.	y	y
Diary	118	-193 D	'Rev.' 15'	**XI[?]**	[Around[?]] the 24th [when] Jupiter [became stationary] to the west […]		
NSA	189	LBAT **1055	Rev. 58	**X**	The 24th, Jupiter stationary in Gemini	y	y
GYT	123	69	Obv. 1	**I**	Around the 15th, Jupiter's acronychal [rising …]		
NSA	194	LBAT 1057	Obv. 2	**I**	The 16th, Jupiter's acronychal [rising …]	n	n
GYT	123	69	Obv. 1-2	**[III[?]]**	The 19th, Jupiter became stationary to the west, [nn] cubits behind β Librae		
NSA	194	LBAT 1057	Obv. 14	**III**	The 19th, Jupiter stationary in Libra.	n	n
GYT	130	73	Obv. 1	**[II]**	The xth, Jupiter's last appearance in Gemini		
NSA	201	LBAT **1059	Obv. 10	**II**	The 13th, Jupiter's last appearance in Gemini	n	n
GYT	130	73	Obv. 1	**[III]**	The 13th, Jupiter's first appearance in Gemini		
NSA	201	LBAT **1059	Obv. 15	**III**	The 12th, Jupiter's first appearance in Gemini.	n	n
GYT	130	73	Obv. 2	**[VII]**	[… when Jupiter became stationary to the east …] 8 fingers above θ Cancri		
NSA	201	LBAT **1059	Rev. 37	**VII**	The 11th, Jupiter stationary in Cancer	n	n
GYT	130	73	Obv. 3	**[IX]**	[The xth, Jupiter's acronychal rising]		
NSA	201	LBAT **1059	Rev. 49	**IX**	The 11th, Jupiter's acronychal rising	n	n

	Year (SE)	Text				Month shift- Seen[?]	Expected[?]
GYT	130	73	Obv. 3	**[XI]**	[… when Jupiter] became stationary [to the west] … 3 cubits below β Geminorum		
NSA	201	LBAT **1059	Rev. 60	**XI**	The 11th, Jupiter stationary in Gemini	n	n
GYT	130	73	Obv. 1	**[III]**	The 13th, Jupiter's first appearance in Gemini		
Alm	201	LBAT 1151	Obv. 7	**III**	The 12th, Jupiter's first appearance in Gemini.	n	n
Diary	138	-173 A	'Rev. 9'	**XII**	The 12th, Jupiter's first appearance in Pisces … (ideal) first on the 11th		
Alm	209	LBAT 1153	Rev. 9	**XII**	The 10th, Jupiter's first appearance in Pisces	n	n
Diary	155	-156 C	Line 19'	**XII**	Until the 30th, when Jupiter became stationary to the west …		
Alm	226	LBAT 1159	Obv. 8	**XII**	[23-28th…] Jupiter stationary in Leo	n	n
GYT	165	86	Obv. 2	**[II]**	[…] first appearance […] (ideal) first appearance on the 19th		
Alm	236	LBAT 1174	Obv. 4	**II**	The 20th, Jupiter's first appearance in the end of ⌜Taurus[?]⌝	n	n
Diary	165	-146	Rev.' 3	**X**	[18-20th] when Jupiter became stationary to the west … 6 fingers in front of μ Geminorum		
Alm	236	LBAT 1174	Rev. 6	**X**	The 19th, Jupiter stationary in Gemini	n	n
Diary	174	-137 E	'Rev. 5'	**XII**	[…] Jupiter's last appearance in Pisces		
Alm	245	LBAT *1179-80	Rev. 22	**XI**	The 25th, Jupiter's last appearance in Pisces	y[?]	n
GYT	175	91	Obv.' 2	**I[?]**	Around the 6th, Jupiter's first appearance in the end of Pisces		
Alm	246	LBAT *1181	Obv. 1	**I**	The 4th, Jupiter's first appearance in Pisces.	n	n
GYT	176	92	Obv. 1	**[I[?]]**	Around the 20+xth, Jupiter's [… first appearance[?]]		
Alm	247	LBAT 1182	Obv. 2	**I**	The 22nd, Jupiter's first appearance in Aries	n	n

	Year (SE)	Text				Month shift- Seen[?]	Expected[?]
Diary	234	-77 A	Rev.' 12-13	**IV**	Around the 23rd, when Jupiter became stationary to the east … 1 cubit 8 fingers behind η Piscium		
Alm	305	LBAT 1195	Obv. 8	**[IV]**	The 22nd, Jupiter stationary in the end of Pisces	n	n
Diary	234	-77 A	Rev.' 39	**VI**	Around the 21st, Jupiter's acronychal rising.		
Alm	305	LBAT 1195	Obv. 11-12	**[VI]**	The 21st, Jupiter's acronychal rising	n	n
Diary	234	-77 B	'Obv.' 20'	**VIII**	Until the 20th, when Jupiter became stationary to the west …		
Alm	305	LBAT 1195	Obv. 17	**[VIII]**	[19th or 20th…] Jupiter stationary in Pisces	n	n
Jupiter's Normal Star passages							
GYT	92	54	Obv.' 7	**VI**	Night of the 12th last part Jupiter … 4 cubits below α Arietis		
NSA	175	LBAT 1041-2	Obv. 15	**VI**	[…]⌜x⌝ Jupiter 4 ⌜x⌝ below α Arietis	n	n
GYT	111	69	Obv. 7	**IX**	Night of the 24th last [part Jupiter] 1 cubit [above θ] Ophiuchi		
NSA	194	LBAT 1057	Rev. 6	**X**	Night of the 17th last part Jupiter ⌜x⌝ cubits above θ [Ophiuchi[?]]	y	y
Venus' events							
Diary	62	-249 B	'Rev.' 4'	**XI**	Night of the 4th last part Venus … below β Capriconi		
NSA	70	MM 86.11.369	Rev. 7'	**XI**	[1st-4th] first part Venus 1 cubit 4 fingers below β Capricorni	n	n
Diary	74	-237	'Obv. 10'	**III**	[Night of the 2]7th last part Venus 1 finger above η Geminorum		
NSA	82	MLC 1860	Obv. 15	**III**	25 last part Venus [...] above η [Geminorum[?]]	n	n
Diary	74	-237	'Obv. 10'	**III**	Night of the 29th last part Venus 1 finger above μ Geminorum		
NSA	82	MLC 1860	Obv. 16	**III**	27th last part Venus ⌜x⌝ above μ Geminorum[?]	n	n

	Year (SE)	Text				Month shift- Seen[?]	Expected[?]
Diary	74	-237	Rev.' 12	**V**	Night of the 21st … last part Venus 4 [fingers] above ϱ Leonis		
NSA	82	MLC 1860	Obv. 26	**V**	18th last part Venus [...] above ϱ [Leo]nis	n	n
Diary	85	-226 A	'Obv. 6'	**II**	[3rd or 4th] [last part Venus] 5 cubits [below β] Arietis		
NSA	93	LBAT 1006	Obv. 5	**II**	Night of the 2nd ⌜last part⌝ Venus [...] below β [Arietis]	n	n
Diary	85	-226 A	Rev.' 14	**III**	Night of the 30th last part Venus 3 cubits below β Tauri		
NSA	93	LBAT 1006	Obv. 16	**IV**	Night of the 1st last part Venus […] below [β/ζ] Tauri[?]	n	n
GYT	88	10	Obv.' 8	**[I]**	Night of the 17th first part Venus 4 ½ cubits above γ Geminorum		
NSA	96	LBAT **1007	Obv. 3	**I**	Night of the 16th first part Venus[?] 4 [cubits x…] above γ Geminorum	n	n
GYT	88	10	Obv.' 9	**III**	The 3rd, Venus' last appearance in the west in Gemini		
NSA	96	LBAT **1007	Obv. 8	**II**	The 29th, Venus' ⌜last appearance[?]⌝ in the west in Gemini	n	n
GYT	88	10	Obv.' 11	**IV**	Night of the 10+[xth last part] Venus 1 ½ cubits […] μ Geminorum		
NSA	96	LBAT **1007	Obv. 12	**IV**	Night of the 11th last part Venus 1 ½ cubits below μ Geminorum.	n	n
GYT	88	10	Obv.' 12	**[V]**	[…] last part of the night Venus 5 ½ cubits below α Geminorum		
NSA	96	LBAT 1008	Obv. 7	**V**	Night of the 1st last part Venus 5 ½ cubits below α Geminorum.	n	n
GYT	88	10	Obv.' 15	**[VI]**	Night of the 30th last part Venus 4 cubits below θ Leonis		
NSA	96	LBAT 1008	Obv. 15-16	**VI**	Night of the 29th last part Venus […] 4 cubits	n	n
GYT	88	10	Obv.' 18	**IX**	Night of the 4th last part Venus 2 fingers above β Scorpii		
NSA	96	LBAT 1008	Rev. 7	**IX**	Night of the 2nd last part Venus 2 ⌜fingers⌝ above β Scorpii	n	n

	Year (SE)	Text				Month shift- Seen[?]	Expected[?]
GYT	88	10	Obv.' 19	**IX**	[…] Venus 2 cubits above α Scorpii		
NSA	96	LBAT 1008	Rev. 8	**IX**	[…]⌜last part Venus⌝ 3 cubits above α Scorpii.	n	n
GYT	88	10	Obv.' 19	**IX**	Night of the 21st last part Venus 1 cubit 4 fingers above θ Ophiuchi		
NSA	96	LBAT 1008	Rev. 9	**IX**	Night of the ⌜19th Venus⌝ 1 cubit 4 fingers above θ Ophiuchi.	n	n
GYT	88	10	Obv.' 20	**[X]**	[…] Venus 2 ½ cubits below β Capricorni; I watched, but I did not see β		
NSA	96	LBAT 1008	Rev. 15	**X**	Night of the ⌜23rd⌝ last part Venus 1 1/3 cubits below β Capricorni	n	n
GYT	98	15	Obv. 13	**[V]**	Night of the 10th last part Venus 3 fingers above α Leonis		
NSA	106	BM 41022+	Obv. 8	**V**	Night of the 8th last part Venus 3 fingers above α Leonis.	n	n
GYT	98	15	Obv. 16	**[XII]**	[… Venus] 3 cubits [above α Tau]ri		
NSA	106	LBAT 1015	Rev. 6	**XII**	[…] first part Venus 3 cubits above α Tauri	n	n
GYT	99	16	'Obv.' 11'	**[II]**	Night of the 22nd first part Venus […] below δ Cancri		
NSA	107	LBAT 1016-18	Obv. 5-6	**II**	Night of the 19th first part Venus […] above [γ/δ] Cancri[?]	n	n
GYT	99	16	'Obv.' 12'-13'	**IV**	Night of the 7th first part Venus 5[?] cubits below θ Leonis		
NSA	107	LBAT 1016-18	Obv. 15	**IV**	⌜Night of the⌝ 6th first part Venus 4 cubits below θ Leonis.	n	n
GYT	99	16	'Obv.' 17'-18'	**XI**	Night of the 11th [last part Venus] ½ cubit below β Capricorni		
NSA	107	LBAT 1016-18	Rev. 5	**XI**	Night of the 9th […]⌜x⌝ Venus 2 cubits below β [Cap]ricorni.	n	n
GYT	99	16	'Obv.' 18'	**XI**	Night of the 25th last part Venus 1 cubit 8 fingers above γ Capricorni		
NSA	107	LBAT 1016-18	Rev. 6	**XI**	Night of the 22nd las[t part] Venus 1 cubit 8 fingers ⌜x⌝ γ Capricorni.	n	n

	Year (SE)	Text				Month shift- Seen?	Expected?
GYT	99	16	'Obv.' 18'-19'	**XI**	Night of the 26th last part Venus 1 cubit 10 fingers above δ Capriconi		
NSA	107	LBAT 1016-18	Rev. 7	**XI**	Night of the 24th last part […] 1 cubit 8 fingers […] [δ Caprico]rni?	n	n
GYT	112	21	'Obv.' 6'	**II**	The 21st, Venus' [last appearance] in the west in Leo		
NSA	120	LBAT 1022	Obv. 7	**II**	The 17th Venus' last appearance in the west in Gemini	n	n
Diary	117	-194 B	Obv. 10-11	**VII**	Night of the 8th last part Venus 2 cubits above α Virginis		
NSA	125	LBAT 1024	Rev. 1	**VII**	Night of the 6th last part Venus […] above ⌜x⌝	n	n
GYT	127	31	Obv.' 11	**IX**	Night of the 3rd first part Venus 4 fingers above γ Capricorni		
NSA	135	LBAT 1026	Obv. 6	**IX**	[...] 4 fingers […γ] Capricorni	n	n
GYT	127	31	Obv.' 12	**IX**	Night of the 5th first part Venus 4 fingers above δ Capricorni		
NSA	135	LBAT 1026	Obv. 7	**IX**	[…]⌜Venus⌝ 4 fingers above δ Capricorni.	n	n
Diary	129	-182 A	'Rev.' 39'	**X**	Around the 12th, Venus […]		
NSA	137	LBAT 1027-8	Rev. 6	**[X]**	The 8th Venus [...] in the east in ⌜x⌝ […]	n	n
Diary	148	-163 B	Obv.' 13	**VIII**	Night of the 28th first part Venus 2 ½ cubits below β Capricorni		
NSA	156	LBAT *1032	Rev. 3	**VIII**	Night of the 26th first part Venus 2 1/3? cubit below β Capricorni	n	n
Diary	148	-163 B	Obv.' 24	**IX**	[Night of the 12th …] Venus 2 fingers above γ Capricorni		
NSA	156	LBAT *1032	Rev. 4	**IX**	Night of the 10th first part Venus 1 finger above γ Capricorni.	n	n
Diary	150	-161 A	'Rev.' 8'-10'	**VI**	[Around the 26th … Venus'] last appearance [in the west] in Libra		
NSA	158	LBAT 1034-5	Rev. 17	**VI**	The 22nd, Venus in […]	n	n

	Year (SE)	Text				Month shift-	
						Seen[?]	Expected[?]
Diary	165	-146	'Obv. 6'	**X**	[The 10th, Venus' first appearance in the west in Aquarius] … (ideal) first appearance on the 9th		
NSA	173	LBAT 1039	Rev. 11	**X**	The 5th, Venus' first appearance in the west in Aquarius	n	n
Diary	167	-144	'Obv. 6'	**[VI]**	[Around the 17th[?]] Venus' first appearance in the west in the end of Virgo		
NSA	175	LBAT 1041-2	Obv. 14	**[VI[?]]**	The 11th, Venus' first appearance in Virgo.	n	n
Diary	170	-141 D	'Obv.' 5'	**VI**	[10th[?]-17th Ve]nus' last appearance in the east in Virgo		
Alm	178	LBAT 1134	Obv. 12	**VI**	[10th-11th] Venus' last appearance in the east in Virgo	n	n
Diary	171	-140 A	'Rev. 16'	**IV**	The 19th, Venus' first appearance in the east in Cancer … (ideal) first on the 15th		
Alm	179	LBAT 1136	Obv. 3	**[IV]**	The 14th, Venus' first appearance in the east in Cancer	n	n
GYT	176	60	Obv.' 29	**[VIII]**	Night of the 27th last part Venus [..]. above θ Ophiuchi		
NSA	184	LBAT 1048	Obv. 7	**VIII**	Night of the 25th last part Venus [...] above [θ Ophiuchi …]	n	n
Diary	179	-132 B	Obv. 3	**VI**	Night of the 3rd … last part Venus 1 cubit 4 fingers below α Leonis		
NSA	187	LBAT 1049-50	Obv. 9	**[VI]**	Night of the 2nd last part Venus 1 cubit 4 fingers below α Leonis	n	n
GYT	179	63	Obv. 11	**[VI[?]]**	[…] Venus was 1 cubit 4 fingers below alpha Leonis		
NSA	187	LBAT 1049-50	Obv. 9	**[VI]**	Night of the 2nd last part Venus 1 cubit 4 fingers below α Leonis	n	n
GYT	180	65	'Obv.' 10'	**[XII[?]]**	Around the 3rd, Venus' last appearance [in] the west in Pisces		
NSA	188	LBAT 1051	Rev. 20	**XI**	The 29th, Venus' last appearance in the west in Pisces.	n	n
Diary	181	-130 D	Rev.' 12	**XII**	[15th] first part Venus 1 ½ cubits below η Tauri		
NSA	189	LBAT **1055	Rev. 68	**XII**	Night of the 13th first part Venus 1 ½ cubits below η Tauri	n	n

	Year (SE)	Text				Month shift- Seen[?]	Expected[?]
Diary	181	-130 D	Rev.' 18	**XII**	Night of the 25th first part Venus […]		
NSA	189	LBAT **1055	Rev. 71	**XII**	Night of the 23rd first part Venus 2 ½ cubits above α Tauri	n	n
GYT	184	68	'Obv.' 9'	**VI**	Night of the 7th last part Venus 5 cubits below θ Leonis		
NSA	192	LBAT 1056	Obv. 5	**VI**	Night of the 5th last part Venus 5 cubits ⌜x⌝ θ [Leonis[?]]	n	n
GYT	184	68	'Obv.' 10'	**VI**	[Ni]ght of the 20+[xth last part] Venus 2/3[?] cubit below γ Virginis		
NSA	192	LBAT 1056	Obv. 9	**VI**	[…] last part Venus 1/3 cubit below γ ⌜Vir⌝ginis	n	n
GYT	184	68	'Obv.' 11'	**VII**	Night of the 29th last part Venus 2 ½ cubits below β Librae		
NSA	192	LBAT 1056	Rev. 5	**VII**	[Night] of the 27th last part Venus 2 ½ cubits below β Librae.	n	n
GYT	184	68	'Obv.' 11'	**VIII**	Night of the 10th last part Venus 8 fingers above β Scorpii		
NSA	192	LBAT 1056	Rev. 7-8	**VIII**	Night of the 8th last part Venus [...]⌜above⌝ β [Scorpii[?] …]	n	n
GYT	186	69	Obv. 8	**II**	Night of the 4th last part Venus 4 cubits below η Piscium		
NSA	194	LBAT 1057	Obv. 5-6	**II**	Night of the 2nd last part Venus 4 cubits below [η] Piscium	n	n
GYT	186	69	Obv. 9	**II**	Night of the 9th last part Venus 5 cubits below β Arietis		
NSA	194	LBAT 1057	Obv. 7	**II**	Night of the 8th last part Venus ⌜4[?]⌝ […] below β Arietis	n	n
GYT	186	69	Obv. 9	**II**	Night of the 13th last part Venus 6[?] [cubits] below α Arietis		
NSA	194	LBAT 1057	Obv. 9	**II**	Night of the 12th last part ⌜Venus⌝ 6 cubits below α Arietis.	n	n
GYT	186	69	Obv. 10	**III[?]**	Night of the 10th last part Venus 2 cubits above α Tauri		
NSA	194	LBAT 1057	Obv. 13	**III**	Night of the 9th last part Venus 2 cubits above α Tauri.	n	n

	Year (SE)	Text				Month shift-	
						Seen[?]	Expected[?]
GYT	186	69	Obv. 10	**III[?]**	Night of the 20th last part Venus 2 ½ cubits below β Tauri		
NSA	194	LBAT 1057	Obv. 13-14	**III**	Night of the 19th[?] last part Venus 2 ½ cubits below β Tauri	n	n
GYT	186	69	Obv. 11	**IV**	Night of the 1st [last part Ve]nus 8 fingers above η Geminorum		
NSA	194	LBAT 1057	Obv. 15	**III**	Night of the 30th last part Venus 8 fingers above η Geminorum.	n	n
GYT	186	69	Obv. 12	**IV**	Night of the 6th last part Venus 2[?] cubits above γ Geminorum		
NSA	194	LBAT 1057	Obv. 18	**IV**	Night of the 5th last part Venus 3 cubits above γ Geminorum.	n	n
GYT	186	69	Obv. 13	**IV**	Night of the 15th[?] [last part Venus] 4 cubits [below] α Geminorum		
NSA	194	LBAT 1057	Obv. 19	**IV**	Night of the 13th last part Venus 4 cubits below α Geminorum	n	n
GYT	186	69	Obv. 13	**IV**	Night of the 18th last part Venus 5 cubits below β Geminorum		
NSA	194	LBAT 1057	Obv. 20	**IV**	Night of the 17th[?] last part Venus 3 cubits below β Geminorum.	n	n
GYT	186	69	Obv. 15	**XI**	Night of the xth first part Venus 2 ½ cubits below η Piscium		
NSA	194	LBAT 1057	Rev. 10	**XI**	Night of the 28th first part Venus 2 ½ cubits below η Piscium.	n	n
GYT	186	69	Obv. 15-16	**[XII]**	[… Venus] 3 ½ cubits [below] β Arietis		
NSA	194	LBAT 1057	Rev. 12	**XII**	Night of the 5th first part Venus 3 ½ cubits below [β] Arietis.	n	n
GYT	186	69	Obv. 16	**[XII]**	Ni[ght of the xth first part] Venus 4 ½ cubits below α Arietis		
NSA	194	LBAT 1057	Rev. 13	**XII**	Night of the 9th first part Venus 4 ½ cubits below α Ari[etis]	n	n
GYT	186	69	Obv. 16	**[XII]**	Night of the 10+[xth first part Venus] 1[?] ½ cubits [below η Tau]ri		
NSA	194	LBAT 1057	Rev. 14	**XII**	[… x+]5th first part Venus 1 ½ cubits below η Tauri	n	n

	Year (SE)	Text				Month shift- Seen?	Expected?
GYT	186	69	Obv. 17	**XII$_2$**	Night of the 14th? first part Venus […] below [β] Tauri		
NSA	194	LBAT 1057	Rev. 19	**XII$_2$**	Night of the 15th first part Venus […] below [β] Tauri	n	n
Diary	187	-124 A	'Obv.' 11'	**II**	Night of the 4th first part Venus […] above [θ? Cancri …]		
NSA	195	LBAT 1058	Obv. 4	**II**	Night of the 3rd first part Venus …	n	n
Diary	193	-118 A	Obv.' 24	**II**	Night of the 3rd first part of the night, Venus was ½ cubit above μ Geminorum		
NSA	201	LBAT **1059	Obv. 8	**II**	Night of the 2nd first part Venus ½ cubit above μ Geminorum	n	n
Diary	193	-118 A	Obv.' 25	**II**	Night of the 5th first part [of the night, Ven]us was [....] above γ Geminorum;		
NSA	201	LBAT **1059	Obv. 9	**II**	Night of the 5th first part Venus ½ cubit above γ Geminorum	n	n
Diary	200	-111 A	Obv.' 6	**I**	Around the 10th, Venus' [last appearance] in the west in Taurus; around the 19th, Venus' first appearance in the east in Taurus		
NSA	208	BM 32230	Obv. 6	**II**	The 16th, Venus […]	y	y
Diary	225	-86 B	Line 20'	**VIII**	The 28th, Venus' first appearance in the east in Sagittarius … (ideal) first on the 24th		
Alm	233	LBAT 1160	Rev. 2	**[VIII]**	The 20th, Venus' first appearance in the east in Sagittarius.	n	n
GYT	228	86	Obv. 12	**II**	Around the 11th, Venus' first appearance in the west in Gemini		
Alm	236	LBAT 1174	Obv. 3	**II**	The 6th, Venus' ⌜first appearance⌝ in the west in Gemini	n	n
GYT	228	86	Obv. 18	**XI**	Around the 10th, Venus' last appearance in the west in the end of Aquarius		
Alm	236	LBAT 1174	Rev. 7	**XI**	The 6th, Venus' last appearance in the west in Aquarius	n	n
GYT	228	86	Obv. 19	**XI**	The 15th, Venus' first appearance in the east in Aquarius … (ideal) first appearance on the 12th		
Alm	236	LBAT 1174	Rev. 7	**XI**	The 8th, Venus' first appearance in the east in Aquarius.	n	n

	Year (SE)	Text				Month shift- Seen[?]	Expected[?]
GYT	237	88	'Obv. 5'	**X**	Around the 5th, Venus' [first appearance in the west in …]		
Alm	245	LBAT *1079-80	Rev. 18	**IX**	[25th-28th x Venus'] first appearance [in the west in x].	n	n
Mercury events							
GYT	50	10	Obv.' 22	**I**	The 7th, Mercury's first appearance in the west in the beginning of Taurus		
NSA	96	LBAT **1007	Obv. 1	**I**	⌜The 14th⌝, Mercury in the west in the beginning of […]	n	n
GYT	50	10	Obv.' 23	**I**	Night of the 25th first part Mercury 1 cubit 4 fingers below β Tauri		
NSA	96	LBAT **1007	Obv. 4	**I**	Night of the 24th first [part] Mercury […] below β Tauri	n	n
GYT	50	10	Obv.' 24	**I**	[…] first part Mercury 1 5/6 cubits above ζ Tauri		
NSA	96	LBAT **1007	Obv. 5	**I**	Night of the 26th first part Mercury 1 1/3 cubits above ζ Tau(ri)	n	n
GYT	50	10	Obv.' 25	**II**	The 13th, Mercury's last appearance in the west in the beginning of Gemini		
NSA	96	LBAT **1007	Obv. 6	**II**	The 13th, Mercury's last appearance in the west in Gemini.	n	n
Diary	50	-261 B	'Obv.' 9'	**IX**	The 20th, Mercury's first appearance in the west in Capricorn … (ideal) first on 19th or 18th		
NSA	96	LBAT 1008	Rev. 8	**IX**	The 18th, Mercury's [first appearance ...] in Capricorn	n	n
GYT	61	16	'Obv.' 21'	**III**	The 30th, [Mercury's] last appearance [in the west in] Cancer		
NSA	107	LBAT 1016-18	Obv. 13	**III**	The 29th, Mercury in the west in Cancer last appearance.	n	n
GYT	61	16	'Obv.' 21'	**IV**	The 24th, Mercury's [first appearance] in [the east in …]		
NSA	107	LBAT 1016-18	Obv. 16	**IV**	The 24th, ⌜Mercury x first appearance[?]⌝	n	n
Diary	62	-249 B	'Obv.' 3'	**IX**	Around the 20th, Mercury's first appearance in the west in Capricorn		
NSA	108	LBAT 1019	Rev. 5	**[IX]**	The 20th, Mercury's first appearance in the west in Capricorn	n	n

	Year (SE)	Text				Month shift- Seen[?]	Expected[?]
Diary	65	-246	Obv.' 13	**II**	The 5th, Mercury's first appearance in the east, omitted		
NSA	111	LBAT 1020	Obv. 4	**II**	The ⌜7th⌝, Mercury's first appearance in the east, omitted	n	n
Diary	65	-246	'Rev. 10'	**VI**	The 12th, Mercury's [last appearance] in the ea[st in Virgo…]		
NSA	111	LBAT 1020	Obv. 13	**VI**	The 12th, Mercury's last appearance in the east in Virgo	n	n
Diary	79	-232	Obv. 28	**IX**	Night of the 9th last part Mercury […] above θ O[phiuchi]		
NSA	125	LBAT 1024	Rev. 5	**[IX]**	Night of the 8th last part Mercury […]	n	n
GYT	83	27	Obv. `7	**I**	The 11th, Mercury's first appearance in the west in Taurus[?]		
Alm	129	LBAT 1123	Obv. 1	**I**	The 12th, Mercury's first appearance in the west in Taurus	n	n
GYT	83	27	Obv. 19	**II[?]**	The xth, Mercury's last appearance in the west in Gemini		
Alm	129	LBAT 1123	Obv. 5	**II**	The 21st, Mercury's last appearance in the west in Gemini	n	n
GYT	83	27	Obv. 19	**III[?]**	The 26th[?], Mercury's [first appearance] in the east …		
Alm	129	LBAT 1123	Obv. 6	**III**	The 24th, Mercury's first appearance in the east in Gemini.	n	n
GYT	83	27	Obv. 20	**[IV]**	[…] Mercury's last appearance in the west in the end of Gemini		
Alm	129	LBAT 1123	Obv. 7	**IV**	The 9th, Mercury's last appearance in the east in the end of Gemini	n	n
GYT	83	26	'Obv.' 3'	**V[?]**	The 11th, Mercury's first appearance in the west in the end of Leo		
Alm	129	LBAT 1123	Obv. 9	**V**	The 11th, Mercury's first appearance in the west in the end of Leo.	n	n
GYT	83	27	Obv. 21	**VII**	The 7th, Mercury's first appearance in the east in Virgo		
Alm	129	LBAT 1123	Obv. 12	**[VII]**	The 5th, Mercury ⌜xxx⌝ […]	n	n

	Year (SE)	Text				Month shift- Seen[?]	Expected[?]
GYT	83	26	'Obv.' 7'	**[XII]**	Around the 7th, Mercury's [last appearance] in the east in …		
Alm	129	LBAT 1123	Rev. 2	**[XII]**	[1st-14th] Mercury's last appearance in the east in Aquarius.	n	n
GYT	83	27	Obv. 25	**XII_2**	The 6th, Mer[cury's first appearance in the west in Aries]		
Alm	129	LBAT 1123	Rev. 4	**XII_2**	The 7th, Mercury's first appearance in the west in Aries.	n	n
Diary	104	-207 A	Obv.' 16	**I**	The 20th[?], Mercury's last appearance in the west in Taurus		
NSA	150	LBAT *1030	Obv. 3-4	**I**	The 1[9th[?] Mercury's] last appearance [in the west in Tau]rus.	n	n
Diary	104	-207 A	Obv.' 31	**II**	The 19th, Mercury's first appearance in the east … omitted		
NSA	150	LBAT *1030	Obv. 8	**II**	The 19th, last part Mercury's [first appearance] in the east in Tau[rus (omitted[?])]	n	n
Diary	104	-207 A	Obv.' 34	**III**	The 5th, Mercury's last appearance in the east … omitted		
NSA	150	LBAT *1030	Obv. 10	**III**	x last part Mercury's last appearance in the east in Gemini [omitted[?]]	n	n
Diary	110	-201 B	Rev. 5-6	**X**	The 13th, Mercury's first appearance in the east in Sagittarius … (ideal) first on the 8th		
NSA	156	LBAT *1032	Rev. 7	**X**	9th ...last part Mercury's first appearance in the east in Sagittarius	n	n
Diary	129	-182 A	'Rev.' 38'	**X**	The 17th, Mercury's first appearance in the east in Capricorn		
NSA	175	LBAT 1041-2	Rev. 7	**[X]**	The 24th, Mer[cury's] first appearance […] in Capricorn	n	n
Diary	133	-178 A	Obv.' 9	**V**	[10th … Mercury's] last appearance [in the east] in Leo		
Alm	179	LBAT 1136	Obv. 6	**V**	The 10th, Mercury's last appearance in the east in Leo	n	n
Diary	133	-178 C	Obv.' 9	**XI**	[The 11th], Mercury's last appearance in the west in P[isces[?]]		
Alm	179	LBAT 1135	Rev. 2	**[XI]**	The 11th, Mercury's last appearance in the west in Pisces.	n	n

	Year (SE)	Text				Month shift- Seen[?]	Expected[?]
Diary	133	-178 C	'Rev. 13'	**XII**	The 29th, Mercury's last appearance in the east in the end of Pisces		
Alm	179	LBAT 1135	Rev. 6	**[XII]**	The 29th, Mercury's last appearance in the east […].	n	n
Diary	138	-173 A	'Rev. 5'	**XII**	The 3rd, Mercury's last appearance in the west in Aries		
NSA	184	LBAT 1048	Rev. 25	**XII**	The 3rd, Mercury's last appearance in the west in Aries.	n	n
Diary	143	-168 A	Obv.' 12	**V**	27th, first appearance in the east in Virgo … (ideal) first on the 25th		
NSA	189	LBAT **1055	Obv. 37-38	**VI**	The 25th, Mercury's first appearance in the east in Virgo	y	y
Diary	143	-168 A	Obv.' 19	**VI**	Night of the 11th last part Mercury 1 cubit 8 fingers [below] γ Virginis		
NSA	189	LBAT **1055	Rev. 40	**VI$_2$**	Night of the 10th ...last part Mercury 1 cubit 8 fingers below γ Virginis	y	y
Diary	143	-168 A	Obv.' 25	**VI**	23rd last appearance in the east in the beginning of Libra		
NSA	189	LBAT **1055	Rev. 43	**VI$_2$**	The 23rd, Mercury's last appearance in the east in Libra.	y	y
Diary	143	-168 A	Rev. 10'-11'	**VIII**	Around the 15th[?] first appearance in the west in Sagittarius		
NSA	189	LBAT **1055	Rev. 48	**VIII**	The 14th, Mercury's first appearance in the west in Sagittarius.	n	n
Diary	143	-168 E	Obv.' 2-3	**IX**	2nd, last appearance in the west in Capricorn		
NSA	189	LBAT **1055	Rev. 51	**IX**	The 2nd, Mercury's last appearance in the west in Capricorn	n	n
Diary	143	-168 A	Obv.' 12	**V**	The 27th, Mercury's first appearance in the <east> in Virgo … (ideal) first on 25th		
Alm	189	LBAT 1141-2	Obv. 12	**VI**	[~26th] ⌜xxxx⌝ first appearance in Virgo	y	y
Diary	143	-168 A	Obv.' 25	**VI**	[The 23rd, Mercury's] last appearance in the east in the beginning of Libra		
Alm	189	LBAT 1141-2	Obv. 13	**[VII]**	⌜xx⌝ Mercury's last appearance in Virgo.	y	y

	Year (SE)	Text				Month shift-	
						Seen[?]	Expected[?]
GYT	146	68	'Obv.' 16'-17'	**VII**	The 29th, Mercury's first appearance in the east in the beginning of Scorpio […] ideal first appearance on the 27th[?]		
NSA	192	LBAT 1056	Rev. 4	**VII**	The 24th, Mercury in the east in Scor[pio …]	n	n
Diary	148	-163 A	Obv.' 2	**II**	The 1st … first part of the night Mercury 1 ½ [cubits] below β Tauri		
NSA	194	LBAT 1057	Obv. 5	**II**	Night of the 1st first part Mercury ⌜xxx⌝ below [β] Tauri	n	n
GYT	148	69	Obv. 21	**II**	Night of the 2nd first part Mercury 1 ½ cubits below β Tauri		
NSA	194	LBAT 1057	Obv. 5	**II**	Night of the 1st first part Mercury ⌜xxx⌝ below [β] Tauri	n	n
Diary	148	-163 A	Obv.' 4	**II**	Night of the 3rd … first part of the night Mercury […] above ζ [Tauri]		
NSA	194	LBAT 1057	Obv. 6	**II**	Night of the 3rd first part Mercury 1 ½ […] above ζ Tauri	n	n
Diary	148	-163 A	Obv.' 11	**II**	Night of the 9th … first part Mercury [… above η Geminorum]		
NSA	194	LBAT 1057	Obv. 8	**II**	Night of the 9th first part Mercury 1 ⌜cubit x⌝ fingers[?] above [η] Geminorum	n	n
GYT	148	69	Obv. 22	**II**	Night of the 9th first part Mercury 1 cubit 4 fingers above η Geminorum		
NSA	194	LBAT 1057	Obv. 8	**II**	Night of the 9th first part Mercury 1 ⌜cubit x⌝ fingers[?] above [η] Geminorum	n	n
Diary	148	-163 A	Obv.' 13-14	**II**	Night of the 11th … first part Mercury 1 2/3 cubits above μ Geminorum		
NSA	194	LBAT 1057	Obv. 8	**II**	Night of the 11th first part Mercury 1 cubit 4 fingers[?] above μ Geminorum	n	n
GYT	148	69	Obv. 22-23	**II**	Night of the 11th first part Mercury 1 cubit 4 fingers above μ Geminorum		
NSA	194	LBAT 1057	Obv. 8	**II**	Night of the 11th first part Mercury 1 cubit 4 fingers[?] above μ Geminorum	n	n
Diary	148	-163 A	Obv.' 18	**II**	Night of the 15th … first part Mercury 4 ½ cubits [above γ Geminorum]		
NSA	194	LBAT 1057	Obv. 10	**II**	Night of the 14th first [part …] ⌜x⌝ Geminorum ⌜xxx⌝	n	n

	Year (SE)	Text				Month shift- Seen?	Expected?
GYT	148	69	Obv. 24	**IV**	The 7th, Mercury's first appearance in the east in Gemini … [(ideal) first appearance] on the 4th		
NSA	194	LBAT 1057	Obv. 18	**IV**	The 4th, Mercury's first appearance in the east ⌜xx⌝	n	n
GYT	148	69	Obv. 25	**IV**	The 23rd, Mercury's last appearance in the east in Cancer		
NSA	194	LBAT 1057	Obv. 21	**IV**	[…x+]3rd Mercury's last appearance in the east in Cancer.	n	n
Diary	148	-163 C	'Obv. 15'	**X**	[… Mercury's] first appearance [in the west] in Capricorn		
NSA	194	LBAT 1057	Rev. 5	**X**	The 3rd, Mercury's first appearance in the west in Capricorn	n	n
GYT	148	69	Obv. 28	**X**	The 5th, Mercury's first appearance in the west in Capricorn ... (ideal) first appearance on the 4th		
NSA	194	LBAT 1057	Rev. 5	**X**	The 3rd, Mercury's first appearance in the west in Capricorn	n	n
Diary	148	-163 C	'Obv. 15'	**X**	Around the 20th, Mercury's last appearance in the west in Aquarius		
NSA	194	LBAT 1057	Rev. 6	**X**	The 20th, Mercury in the west in Aquarius ⌜x⌝ […]	n	n
GYT	148	69	Obv. 28-29	**X**	[…Mercury's last appearance in the west] in Aquarius: from the 20th, when I watched I did not see it		
NSA	194	LBAT 1057	Rev. 6	**X**	The 20th, Mercury in the west in Aquarius ⌜x⌝ […]	n	n
Diary	148	-163 C	Rev.' 4	**XI**	The 10th, Mercury's [first] appearance in the east in Capricorn		
NSA	194	LBAT 1057	Rev. 8	**XI**	The 8th, Mercury's first appearance in the east in Capricorn.	n	n
GYT	148	69	Obv. 29	**XI**	The 10th, Mercury's first appearance in the east in Capricorn,… (ideal) first appearance on the 8th		
NSA	194	LBAT 1057	Rev. 8	**XI**	The 8th, Mercury's first appearance in the east in Capricorn.	n	n
GYT	148	69	Obv. 30	**XI**	Night of the 25th last part Mercury ½ cubit above γ Capricorni		
NSA	194	LBAT 1057	Rev. 8-9	**XI**	Night of the 24th last part Mercury ½ cubit above ⌜x⌝ […] Capricorni	n	n

	Year (SE)	Text				Month shift- Seen[?]	Expected[?]
GYT	148	69	Obv. 31	**XI**	Night of the 27th last part Mercury ½ cubit above δ Capricorni		
NSA	194	LBAT 1057	Rev. 9-10	**XI**	Night of the 26th last part Mercury above δ [Capricorni …]	n	n
Diary	148	-163 C	'Rev.' 3'	**XII**	Around the 14th, Mercury's last appearance in the east in Aquarius (alt: "the end of Aquarius")		
NSA	194	LBAT 1057	Rev. 14	**XII**	[x+]5th Mercury's last appearance in the east in the end of Aquarius.	n	n
GYT	148	69	Obv. 31-32	**XII**	The 17th, Mercury's last appearance in the east in Pisces, from the 14th in the end of Aquarius, when I watched I did not see it		
NSA	194	LBAT 1057	Rev. 14	**XII**	[x+]5th Mercury's last appearance in the east in the end of Aquarius.	n	n
GYT	155	73	Obv. 31'	**[I]**	Night of the 9th first part Mercury 1 cubit above α Tauri		
NSA	201	LBAT **1059	Obv. 2-3	**I**	Night of the 8th first part Mercury 4 cubits above α Tauri.	n	n
GYT	155	73	Obv. 32'	**[I]**	Night of the 17th[?] first part [Mercury …] below β Tauri		
NSA	201	LBAT **1059	Obv. 3-4	**I**	Night of the 16th first part Mercury 1 ½ cubits below β Tauri	n	n
Diary	155	-156 A	'Obv.' 8'	**I**	Night of the 19th first part Mercury 1 ½ cubits above ζ Tauri		
NSA	201	LBAT **1059	Obv. 4	**I**	Night of the 18th first part Mercury 1 ½ cubits above ζ Tauri	n	n
GYT	155	73	Obv. 32'	**[I]**	[Night of the 1]9th first part Mercury 1 ½ cubits above ζ Tauri		
NSA	201	LBAT **1059	Obv. 4	**I**	Night of the 18th first part Mercury 1 ½ cubits above ζ Tauri	n	n
Diary	155	-156 A	'Obv.' 12'	**I**	[26th] first part Mercury 1 cubit 4 fingers above η Geminorum		
NSA	201	LBAT **1059	Obv. 5	**I**	Night of the 25th first part Mercury 1 cubit 4 fingers above η Geminorum	n	n
GYT	155	73	Obv. 33'	**[I]**	Night of the 10+[xth first part Mercury] 1 cubit 4 fingers [above η Geminorum]		
NSA	201	LBAT **1059	Obv. 5	**I**	Night of the 25th first part Mercury 1 cubit 4 fingers above η Geminorum	n	n

	Year (SE)	Text				Month shift- Seen[?]	Expected[?]
Diary	155	-156 A	'Obv.' 14'	**I**	[28th] first part Mercury […] above μ Geminorum		
NSA	201	LBAT **1059	Obv. 5-6	**I**	Night of the 27th first part Mercury 1 cubit 4 fingers above μ Geminorum.	n	n
GYT	155	73	Obv. 34'	**[I]**	Night of the 28th first part Mercury […] above μ Ge[minorum]		
NSA	201	LBAT **1059	Obv. 5-6	**I**	Night of the 27th first part Mercury 1 cubit 4 fingers above μ Geminorum.	n	n
GYT	155	73	Obv. 34'-35'	**[II]**	[Night of the xth first part Mercury] 4 cubits above γ Geminorum		
NSA	201	LBAT **1059	Obv. 8-9	**II**	2nd first part Mercury 4 cubits above γ Geminorum	n	n
GYT	155	73	Obv. 35'-36'	**[III]**	[The xth, Mercury's first appearance in the east in Gemini], … (ideal) first appearance on the 14th		
NSA	201	LBAT **1059	Obv. 15	**III**	The 14th Mercury's first appearance in the west in Gemini.	n	n
GYT	155	73	Obv. 37'	**V**	Around the 5th, Mercury's first appearance in the west in Vir[go[?]]		
NSA	201	LBAT **1059	Obv. 26	**V**	The 5th, Mercury's first appearance in the west in Virgo.	n	n
GYT	155	73	Obv. 37'	**V**	Around the 27th, [Mercury's last appearance in the west in …]		
NSA	201	LBAT **1059	Obv. 30	**V**	The 27th, Mercury's last appearance in the west in Virgo.	n	n
GYT	155	73	Obv. 38'	**VI**	The 28th, Mercury's [first appearance] in the east in Virgo		
NSA	201	LBAT **1059	Rev.. 37	**VI**	The 26th, Mercury's first appearance in the east in Virgo	n	n
GYT	155	73	Obv. 38'	**[VII]**	[Night of the 6th[?], last part Mercury] 2 cubits [above] α Virginis		
NSA	201	LBAT **1059	Rev. 36	**VII**	Night of the 7th last part Mercury 2 cubits above α Virginis.	n	n
GYT	155	73	Obv. 40'	**[IX]**	The 9th[?] Mercury's [first appearance] in the west in [Capricorn …]		
NSA	201	LBAT **1059	Rev. 50	**IX**	The 13th, Mercury's first appearance in the west in Capricorn	n	n

	Year (SE)	Text				Month shift- Seen[?]	Expected[?]
GYT	155	73	Rev. 1-2	**[X]**	[The xth, Mercury's first appearance] in the east in Capricorn, 1 cubit behind β Capricorni … (ideal) first appearance on the 14th		
NSA	201	LBAT **1059	Rev. 54	**X**	The 14th, Mercury's first appearance in the east in Capricorn(?).	n	n
GYT	155	73	Rev. 3	**XI**	The 28th, Mercury's last appearance in the east in Aquarius, from the 26th, when I watched I did not see it		
NSA	201	LBAT **1059	Rev. 61	**XI**	The 26th, Mercury's last appearance in the east in Capricorn	n	n
GYT	156	73	Rev. 4	**[I]**	The 1st, Mercury's first appearance in the west in Aries		
NSA	201	LBAT **1059	Rev. 70	**XII**	The 29th, Mercury's first appearance in the west in Aries.	n	n
Diary	163	-148	Line 8'	**IX**	The 22nd, Mercury's first appearance in the east in Sagittarius		
Alm	209	LBAT 1153	Rev. 3	**IX**	The 12th, Mercury's first [appearance] in the east in Sagittarius	n	n
Diary	174	-137 D	Rev.' 29	**XI**	Around the 2nd, Mercury's first appearance in the east in the end of Capricorn		
Alm	220	LBAT 1158	Rev. 2	**[XI]**	The 2nd, Mercury ⌜xxx⌝	n	n
Diary	180	-131 B	Obv. 2-4	**XI**	The 22nd, Mercury's first appearance in the east in Aquarius … (ideal) first on the 19th		
Alm	226	LBAT 1159	Obv. 5	**XI²**	[…] Mercury's first appearance in the east in Aquarius	n	n
Diary	187	-124 A	'Obv.' 22'	**II**	The 22nd, Mercury's last appearance in the west in the beginning of Cancer		
Alm	233	LBAT 1160	Obv. 3	**[II]**	The 22nd, Mercury's last appearance in the west in the beginning of Cancer	n	n
Diary	187	-124 A	'Obv.' 33'	**III**	Around the 22nd, Mercury's [first appearance in the east in Gemini …]		
Alm	233	LBAT 1160	Obv. 5	**[III]**	The 22nd, Mercury's first appearance in the east in the end of Gemini	n	n
Diary	187	-124 A	'Rev.' 25'	**VI**	The 1st, Mercury's [first appearance] in the west in Libra		
Alm	233	LBAT 1160	Obv. 10	**[VI]**	The 1st, Mercury's first appearance in the west in ⌜x⌝	n	n

	Year (SE)	Text				Month shift- Seen?	Expected?
Diary	187	-124 B	'Obv.' 18'	**IX**	Around the 21st, Mercury's first appearance in the west in Capricorn		
Alm	233	LBAT 1160	Rev. 4	**[IX]**	The 21st, Mercury's first appearance in the west in Capricorn.	n	n
Diary	187	-124 B	'Rev.' 7'	**X**	Around the 28th, Mercury's first appearance in the east in the end of Capricorn		
Alm	233	LBAT 1160	Rev. 7	**[X]**	The 28th, Mercury' first appearance in the east in the beginning of Aquarius.	n	n
Diary	188	-123 A	'Obv. 11'	**III**	The 19th, Mercury's first appearance in the east in Gemini … (ideal) first on the 16th		
Alm	234	LBAT **1161	Obv. 6	**[III]**	[13th-23rd…] first appearance [...] Gemini.	n	n
Diary	188	123 A	Rev.' 5	**IV**	[The x+]1st, Mercury's last appearance in the east in the end of Gemini		
Alm	234	LBAT **1167	Obv. 7	**[IV]**	The 1st, Mercury's last appearance in the east in the end of Gemini.	n	n
Diary	188	123 C	Line 11'	**V**	Around the 10th, Mercury's [first appearance in the west in Virgo …]		
Alm	234	LBAT **1167	Obv. 9	**[V]**	The 10th, Mercury in the west in Virgo […]	n	n
GYT	190	86	Obv. 20	**II**	Around the 6th, Mercury's first appearance in the west[sic] omitted		
Alm	236	LBAT 1174	Obv. 3	**II**	[7th-14th] ⌜x⌝ Mercury's first appearance in the east, omitted	n	n
GYT	190	86	Obv. 20-21	**II**	Around the 20th, Mercury's last appearance in the east, omitted		
Alm	236	LBAT 1174	Obv. 4	**II**	The 20th, Mercury's last appearance in the east, omitted	n	n
Diary	190	-121	'Obv. 4'	**III**	Around the 17th, Mercury's [first appearance] in the west in Cancer …		
Alm	236	LBAT 1174	Obv. 5	**III**	The 15th, Mercury's first appearance in the west in Cancer.	n	n
GYT	190	86	Obv. 21	**III**	The 19th, Mercury's first appearance in the west in Cancer … (ideal) first appearance on the 17th		
Alm	236	LBAT 1174	Obv. 5	**III**	The 15th, Mercury's first appearance in the west in Cancer.	n	n

	Year (SE)	Text				Month shift-Seen?	Expected?
GYT	190	86	Obv. 22	**IV**	Around the 23rd, Mercury's last appearance in the west in Leo		
Alm	236	LBAT 1174	Obv. 8-9	**IV**	The 23rd, Mercury's last appearance in the west in the end of Leo	n	n
GYT	190	86	Obv. 22	**V**	The 24th, Mercury's first appearance in the east in Leo … (ideal) first appearance on the 21st		
Alm	236	LBAT 1174	Obv. 10	**V**	The 21st, Mercury's first appearance in the east in Leo.	n	n
GYT	190	86	Obv. 23	**VI**	[last] appearance of Mercury in Virgo, when I watched from the 12th I did not see it		
Alm	236	LBAT 1174	Obv. 11-12	**VI**	The 12th, Mercury's last appearance in the east in Virgo	n	n
GYT	190	86	Obv. 23	**VIII**	Around the 8th, Mercury's first appearance in the west in Sagittarius		
Alm	236	LBAT 1174	Rev. 1	**VIII**	The 8th, Mercury's first appearance in the east in Sagittarius	n	n
GYT	190	86	Obv. 23-24	**VIII**	Around the 23rd, Mercury's last appearance in the west in Sagittarius		
Alm	236	LBAT 1174	Rev. 2	**VIII**	The 23rd, Mercury's last appearance in the west in Sagittarius.	n	n
GYT	190	86	Obv. 24	**IX**	Around the 7th, Mercury's first appearance in the east in Sagittarius		
Alm	236	LBAT 1174	Rev. 3	**IX**	The 7th, Mercury's first appearance in the east in Sagittarius.	n	n
GYT	190	86	Obv. 24	**X**	Around the 13th, Mercury's last appearance in the east in Capricorn		
Alm	236	LBAT 1174	Rev. 6	**X**	The 23rd, Mercury's last appearance in the east in Capricorn.	n	n
GYT	190	86	Obv. 25	**XI**	The 24th, Mercury's first appearance in the west in Pisces … (ideal) first appearance on the 23rd		
Alm	236	LBAT 1174	Rev. 8	**XI**	The 23rd, Mercury's [first appearance] in the east in Pisces.	n	n
GYT	190	86	Obv. 26	**XII**	Around the 17th, Mercury's last appearance in the west in Aries		
Alm	236	LBAT 1174	Rev. 9-10	**XII**	The 27th, Mercury's last appearance in the west in Aries	n	n

	Year (SE)	Text				Month shift- Seen[?]	Expected[?]
GYT	199	88	'Obv. 8'	**III**	The 29th, Mercury's last appearance in the west in …		
Alm	245	LBAT *1179-80	Obv. 5-6	**III**	The 22nd, Mercury's last appearance [in x in] Cancer.	n	n
GYT	199	88	'Obv. 9'	**[IV]**	(ideal) first appearance in the east on the 22nd		
Alm	245	LBAT *1179-80	Obv. 8	**IV**	The 22nd, Mercury's first appearance in the east in Cancer.	n	n
GYT	199	88	'Obv. 10'-11'	**VII**	Around the 18th, [Mercury's last appearance] in the west … [omitted]		
Alm	245	LBAT *1179-80	Obv. 13-14	**VII**	The 15th, Mercury's last appearance in the west omitted	n	n
GYT	199	88	'Obv. 11'	**VIII**	The 8th, Mercury's [first appearance] in the east in …(ideal) first appearance on the 5th		
Alm	245	LBAT *1179-80	Rev. 15-16	**VIII**	⌜The 8th[?]⌝ Mercu]ry's first appearance in the east in the end of Libra	n	n
GYT	199	88	'Obv. 13'	**X**	The 22nd[?] Mercury's first appearance in the west in Aquarius… (ideal) first appearance on the 21st		
Alm	245	LBAT *1179-80	Rev. 20	**X**	⌜The 17th[?]⌝ Mercury's first appearance in the west in ⌜Aquarius⌝	n	n
Diary	200	-111 A	Obv.' 6	**I**	The 10th, Mercury's first appearance [in the west in] Taurus … [(ideal) first on the 8th …]		
Alm	246	LBAT *1181	Obv. 3	**II**	The 8th[?], Mercury's first appearance in the west in Taurus.	y	y
Diary	200	-111 B	'Obv.' 4'	**II**	Around the 15th, Mercury's [last appearance] in the west in the beginning of Ca[ncer …]		
Alm	246	LBAT *1181	Obv. 5	**III**	The 15th, Mercury's last appearance in the west in Cancer.	y	y
GYT	201	92	Obv. 11	**I**	The 4th, Mer[cury's] first appearance […] (ideal) first appearance on the 3rd[?]		
Alm	247	LBAT 1182	Obv. 1	**I**	The 2nd, ⌜Mercury[?]⌝'s first appearance in the west in Taurus	n	n
GYT	201	92	Obv. 14	**[IV]**	[The x]+1st, Mercury's last appearance in the east in the beginning of Gemini … from the 28th of Month III when I watched [I did not see it…]		
Alm	247	LBAT 1182	Obv. 6	**III**	The 25th, Mercury's last appearance in the east in Gemini	n	n

	Year (SE)	Text				Month shift-Seen[?]	Month shift-Expected[?]
Diary	202	-109 A	'Obv.' 18'	**[IX]**	The 9th, Mercury's first appearance [in the west …] (ideal) first on the 7th in Sagittarius.		
Alm	248	LBAT 1183	Rev. 3	**[IX]**	The 7th, ⌜Mercury's first appearance in the west in x⌝	n	n
Diary	251	-60	'Obv. 5'	**VIII**	The 7th, Mercury's [last appearance] in the west in Scor[pius]		
Alm	297	LBAT 1187	Obv. 9	**[VIII]**	The 8th, Mercury in the east (error for west) in the end of Scorpio […]	n	n
Diary	251	-60	Rev.' 4	**VIII**	Around the 23rd, Mercury's first appearance in the east in Scorpius		
Alm	297	LBAT 1187	Obv. 10	**[VIII]**	The 13th, […] first appearance in the east in Scorpio	n	n
Saturn events							
Diary	48	-263	'Obv.' 14'	**IX**	The 18th, Saturn's acrony[chal rising]		
NSA	107	LBAT 1016-18	Rev. 3	**X**	The 13th, Saturn's acronychal rising.	y	y
GYT	48	18	'Obv. 5'	**IX**	Around the 18th, Saturn's acronychal rising		
NSA	107	LBAT 1016-18	Rev. 3	**X**	The 13th, Saturn's acronychal rising.	y	y
GYT	48	18	'Obv. 5'	**XI**	Night of the 10th first part, Saturn 1 finger [above δ Can]cri		
NSA	107	LBAT 1016-18	Rev. 11	**XII**	⌜x⌝ Saturn 2 fingers above δ Cancri	y	y
Diary	57	-254	Rev.' 1	**X**	Night of the 1st last part Saturn 8 fingers above β Scorpii		
NSA	116	LBAT 1021	Rev. 7	**IX**	Night of the 28th last part Saturn 8 fingers above β Scorpii …	n	n
Diary	74	-237	Rev.' 8-9	**V**	Night of the 6th … last part Sat[urn] 3 fingers [… ζ Tau]ri		
NSA	133	MLC 1885	Obv. 9	**V**	Night of the 3rd last part Saturn 6 fingers above ζ Tauri	n	n
Diary	114	-197 B	'Rev. 4'	**XI**	Around the 10th, when Saturn became stationary… ½ cubit in front of α Librae		
NSA	173	LBAT 1039	Rev. 16	**XI**	The 5th, Saturn stationary in Libra	n	n

	Year (SE)	Text				Month shift- Seen[?]	Expected[?]
Diary	129	-182 A	'Obv.' 3'	**I**	The 23rd, Saturn's first app[earance] in the end of Pisces		
NSA	188	LBAT 1051	Obv. 3	**I**	The 14th, Saturn's first appearance in the beginning of Aries	n	n
GYT	129	64	'Obv.' 8'	**I**	[The xth, Saturn's first appearance in Pisces]		
NSA	188	LBAT 1051	Obv. 3	**I**	The 14th, Saturn's first appearance in the beginning of Aries	n	n
GYT	133	68	'Obv.' 23'	**[VII]**	[… Saturn] 6 fingers above ζ Tauri		
NSA	192	LBAT 1056	Rev. 3	**VII**	[…] 21st last part Saturn 6 fingers above [ζ] Tauri[?]	n	n
GYT	133	68	'Obv.' 23'	**VIII**	The 11th, Saturn's acronychal rising		
NSA	192	LBAT 1056	Rev. 7	**VIII**	The 6th, Saturn's acronychal rising	n	n
GYT	135	69	Obv. 34	**II**	The 17th, Saturn's last appearance in Gemini		
NSA	194	LBAT 1057	Obv. 12	**III**	The 5th, Saturn ⌜xx⌝ […last appearance[?]]	y	y
GYT	135	69	Obv. 35	**III**	The 21st, Saturn's first appearance in Gemini		
NSA	194	LBAT 1057	Obv. 19	**IV**	The 13th, Saturn's first appearance in Gemini.	y	y
GYT	135	69	LE 1	**[IX[?]]**	Around the 11th, Saturn's acronychal rising		
NSA	194	LBAT 1057	Rev. 5	**X**	The 6th, Saturn's acronychal rising	y	y
GYT	135	69	LE 2	**XI**	Around the 11th Saturn became stationary to the west 6 fingers in front of α Geminorum…		
NSA	194	LBAT 1057	Rev. 13	**XII**	The 10th, Saturn stationary in Gemini	y	y
GYT	142	73	Rev. 16	**[II]**	[The xth] when [Saturn became stationary to the west … x+]½ cubits in front of [γ Virginis]		
NSA	201	LBAT **1059	Obv. 8	**II**	The 1st, Saturn stationary in Virgo	n	n

	Year (SE)	Text				Month shift- Seen[?]	Expected[?]
GYT	142	73	Rev. 17	**IV**	Night of the 12th first part, Saturn […] fingers [below γ Virginis]		
NSA	201	LBAT **1059	Obv. 16	**III**	Night of the 20th first part Saturn 6 fingers below γ Virginis.	n	n
GYT	142	73	Rev. 17-18	**V**	The 27th, Saturn's last appearance in Virgo: from the 23rd, when I watched, I did not see it.		
NSA	201	LBAT **1059	Obv. 27	**V**	The 14th, Saturn's last appearance in Virgo	n	n
GYT	142	73	Rev. 18-19	**[VII]**	[The xth, Saturn's] first appearance [in Virgo …] (ideal) first on the 12th.		
NSA	201	LBAT **1059	Obv. 33	**VI**	The 24th, Saturn's first appearance in Virgo	n	n
GYT	142	73	Rev. 19	**IX**	Night of the 4[+xth last part Saturn x]+1 cubits [above α Virginis].		
NSA	201	LBAT **1059	Rev. 43	**VIII**	Night of the 12th last part Saturn 1 ½ cubits above α Virginis	n	n
GYT	142	73	Rev. 19-20	**XI**	Around until the 7th[?], when Saturn became stationary to the east … [behind α Virginis]		
NSA	201	LBAT **1059	Rev. 60	**XI**	The 2nd, Saturn stationary in the beginning of Libra.	n	n
GYT	142	73	Rev. 18-19	**[VII]**	[The xth, Saturn's] first appearance [in Virgo …] (ideal) first on the 12th.		
Alm	201	LBAT 1151	Obv. 13	**VI**	The 24th, Saturn's first appearance in Virgo.	n	n
GYT	177	86	Obv. 27	**II**	Around the 4th, Saturn's acronychal rising		
Alm	236	LBAT 1174	Obv. 1	**I**	The 27th, Saturn's ⌜acronychal rising⌝	n	n
GYT	177	86	Obv. 27	**IV**	Until the 8th, when Saturn became stationary to the west…		
Alm	236	LBAT 1174	Obv. 7	**IV**	The 1st, Saturn stationary in Scorpio.	n	n
Diary	177	-134 B	Obv.' 19	**VIII**	The 4th, setting of Saturn in Scorpius … from the 1st not seen		
Alm	236	LBAT 1174	Obv. 13	**VII**	The 21st, Saturn's last appearance in Scorpio	n	n

	Year (SE)	Text				Month shift- Seen[?]	Expected[?]
GYT	177	86	Obv. 28	**VIII**	The 4th, Saturn's last appearance in Scorpio, from the 2nd when I watched I did not see it		
Alm	236	LBAT 1174	Obv. 13	**VII**	The 21st, Saturn's last appearance in Scorpio	n	n
GYT	178	86	Obv. 30	**I**	Around the 6th, when Saturn became stationary to the east…		
Alm	236	LBAT 1174	Rev. 10	**XII**	The 29th, Saturn ⌜stationary⌝ in Sagittarius	n	n
GYT	186	88	'Obv. 16'	**IV**	Around until the 14th, Saturn became stationary to the east in Pisces		
Alm	245	LBAT *1079-80	Obv. 7	**IV**	The 7th, Saturn ⌜stationary⌝ [in] P[isce]s	n	n
Mars' phenomena							
Diary	22	-289	Rev.' 5	**IV**	The 8th, Mars' [first appearance] in the east in Cancer		
NSA	101	BCMA 1846-1982	Obv. 14	**IV**	The 1st, Mars' last (error for first[?]) appearance in the end of Gemini	n	n
GYT	26	14	'Obv. 3'	**III**	The 23rd, Mars' last appearance in Cancer		
NSA	105	LBAT *1011	Obv. 6	**II**	The 23rd, Mars' last appearance in Cancer	y	y
Diary	27	-284	Obv.' 6'	**VII**	Around the 15th, when Mars became stationary to the west … 2/3 cubit below η Piscium		
NSA	106	BM 41022+	Rev. 2	**VII**	15th, Mars stationary[?] in Pisces	n	n
GYT	50	27	Obv. 33	**XI**	The 20th[?], Mars' acronychal rising		
Alm	129	LBAT 1123	Rev. 1	**XI**	The 14th, Mars' acronychal rising.	n	n
Diary	50	-261 B	'Rev.' 5'	**XII**	Around the 23rd, when Mars became stationary to the west behind ϱ Le]onis		
Alm	129	LBAT 1123	Rev. 3	**[XII]**	[23-28th…] Mars stationary in Leo	n	n
GYT	50	27	Obv. 33	**XII**	Until the 22nd, when Mars [became stationary] to the west...		
Alm	129	LBAT 1123	Rev. 3	**[XII]**	[23-28th…] Mars stationary in Leo	n	n

	Year (SE)	Text				Month shift- Seen[?]	Expected[?]
Diary	77	-234 B	Obv.' 27	**IX**	The 8th, Mars' first appearance in Scorpius		
NSA	156	LBAT *1032	Rev. 4	**IX**	The 4th last part Mars' first appearance in the east in Scorpio.	n	n
Diary	104	-207 A	Obv.' 28	**II**	Around the 20th, when Mars became stationary to the east … 2 cubits in front of γ Capricorni		
Alm	183	LBAT 1137-8	Obv. 5	**II**	The 20th, Mars stationary in Capricorn	n	n
GYT	115	69	LE 3	**XII**	Around the 8th, Mars' last appearance in the end of Pisces		
NSA	194	LBAT 1057	Rev. 12	**XII**	The 8th, Mars' last appearance in the end of Pisces.	n	n
Diary	122	-189 B	'Obv.' 14'	**VII**	1st, Mars [first appearance in the beginning of Libra]		
NSA	201	LBAT **1059	Rev. 36	**VII**	The 8th, Mars' first appearance in Libra	n	n
Diary	122	-189 A	'Obv.' 16'	**III**	[11th[?]] Mars' last appearance in Cancer		
Alm	201	LBAT 1151	Obv. 8	**III**	ʿThe 22nd, Mars' last appearance in Cancer.	n	n
Diary	122	-189 B	'Obv.' 14'	**VII**	The 1st, Mars' [first appearance in the beginning of Libra]		
Alm	201	LBAT 1151	Obv. 14	**VII**	The 8th, Mars' ⌜first appearance[?] in Leo⌟	n	n
GYT	157	86	Obv. 38	**[IX]**	Around the 2nd, Mars' acronychal rising		
Alm	236	LBAT 1174	Rev. 3	**IX**	The 6th, ⌜Mars' acronychal rising⌝	n	n
GYT	166	88	'Obv. 18'-19'	**I**	Around until the 10th, Mars became stationary to the east		
Alm	245	LBAT **1179-80	Obv. 2	**I**	[2]7th Mars ⌜stationary⌝ in Sagittarius	n	n
GYT	166	88	'Obv. 19'	**II**	Around the 20th, Mars' acronychal rising.		
Alm	245	LBAT **1179-80	Obv. 4	**II**	The 29th, Mars' acronychal rising.	n	n

	Year (SE)	Text				Month shift- Seen[?]	Expected[?]
GYT	166	88	'Obv. 19'-20'	**III**	Until the 25th, Mars became stationary to the west		
Alm	245	LBAT **1179-80	Obv. 7	**IV**	The 3rd, Mars stationary in the beginning of Sagittarius.	n	n
Diary	167	-144	'Obv. 13'	**VI**	Around the 13th, Mars' first appearance in Virgo		
Alm	246	LBAT *1181	Obv. 11	**[VI]**	⌜x⌝ Mars' first appearance in Leo.	n	n
Diary	218	-93 A	Rev.' 10	**IV**	Around the 17th, Mars' last appearance in Leo		
Alm	297	LBAT 1187	Obv. 2	**[IV]**	The 23rd[?] Mars' last appearance in Leo.	n	n
Diary	226	-85 C	'Rev. 19'	**XII**	Around the 27th, Mars [last appearance] in Aries		
Alm	305	LBAT 1195	Rev. 10	**[XII$_2$]**	[1st-3rd] ⌜x⌝ last appearance in Aries.	n	n
Mars' NS passages							
GYT	49	10	'Rev. 3'-4'	**I**	Night of the 5th first part Mars, 2 ½ cubits below ε Leonis		
NSA	96	LBAT **1007	Obv. 4	**I**	⌜Night of the⌝ 21st first part Mars 3 cubits below[?] ε Leonis	n	n
GYT	49	10	'Rev. 4'	**I**	Night of the 25th first part Mars 14 fingers above α Leonis		
NSA	96	LBAT **1007	Obv. 6	**II**	Night of the 11th first part Mars 14 fingers above α Leonis	n	n
GYT	49	10	'Rev. 4'-5'	**II**	Night of the 9th first part Mars ½ cubit above ϱ Leonis		
NSA	96	LBAT **1007	Obv. 7	**II**	Night of the 25th first part Mars […] above ϱ [Leonis]	n	n
GYT	49	10	'Rev. 5'	**II**	Night of the 28th first part Mars 4 cubits below θ Leonis		
NSA	96	LBAT **1007	Obv. 9	**III**	Night of the 14th first part ⌜Mars⌝ 4 ⌜cubits⌝ below θ Leonis	n	n
GYT	49	10	'Rev. 6'	**[III]**	[…] first part Mars 1 finger above β Virginis, it came close		
NSA	96	LBAT **1007	Obv. 11	**IV**	x first part Mars 1 finger above β Virginis	n	n

	Year (SE)	Text				Month shift-Seen?	Expected?
GYT	49	10	'Rev. 7'	**IV**	Night of the 29th first part Mars 1 cubit above α Virginis		
NSA	96	LBAT **1007	Obv. 11	**IV**	x first part Mars 1 finger above β Virginis	n	n
GYT	49	10	'Rev. 7'-8'	**V**	Night of the 30th, 8 fingers [… α Lib]rae		
NSA	96	LBAT 1008	Obv. 14	**VI**	Night of the 16th first part Mars 8 fingers below α Librae.	n	n
Diary	57	-254	Rev.' 1	**X**	Night of the 3rd first part Mars 1 5/6 cubits below η Piscium		
NSA	104	LBAT 1010	Rev. 10	**X**	Night of the 19th first part Mars […] below [η Piscium]	n	n
GYT	58	14	'Obv. 4'	**I**	Night of the 19th first part Mars […] above η Geminorum		
NSA	105	LBAT *1011	Obv. 1	**I**	Night of the 5th first part Mars 20 fingers above η Geminorum	y	y
GYT	58	14	'Obv. 5'	**I**	[…] Mars 20 fingers above μ Geminorum		
NSA	105	LBAT *1011	Obv. 1	**I**	Night of the 9th first part Mars 20 fingers above μ Geminorum	y	y
GYT	58	14	'Obv. 5'	**II**	Night of the 1st first part Mars […] above γ Geminorum		
NSA	105	LBAT *1011	Obv. 2	**I**	Night of the 18th first part Mars 3 cubits above γ Geminorum.	y	y
GYT	58	14	'Obv. 6'	**II**	[Night of the xth first] part Mars 3 ½ cubits below α Geminorum		
NSA	105	LBAT *1011	Obv. 4	**II**	[Night of the 1st] first part Mars 3 ½ cubits below α Geminorum	y	y
GYT	58	14	'Obv. 6'	**II**	Night of the 23rd first part Mars 2 ½ cubits below β Geminorum		
NSA	105	LBAT *1011	Obv. 5	**II**	Night of the 9th first part Mars […] below β Geminorum	y	y
GYT	60	18	Rev.' 3	**[I]**	Night of the 17th first part Mars 2 [cubits] below α Geminorum		
NSA	107	LBAT 1016-18	Obv. 3	**II**	3rd first part Mars 3 ½ cubits below α Geminorum.	n	n
Diary	60	-251	'Rev. 4'-5'	**XII**	Night of the 5th [last part] Mars 5/6 cubit above δ Capricorni		
NSA	107	LBAT 1016-18	Rev. 1 3-14	**XII**	Night of the 22nd last part Mars […] above [δ Capricorni]	n	n

	Year (SE)	Text				Month shift- Seen[?]	Expected[?]
GYT	60	16	'Rev.' 2'	**XII**	Night of the 3rd, last [part Mars .. above δ Capricorni]		
NSA	107	LBAT 1016-18	Rev. 1 3-14	**XII**	Night of the 22nd last part Mars […] above [δ Capricorni]	n	n
GYT	147	69	LE 4	**II**	Night of the 20th first part Mars 1 cubit below γ Virginis		
NSA	194	LBAT 1057	Obv. 13	**III**	[5th-9th… Mars] 1 cubit below γ Virginis	n	n
GYT	147	69	Le 4-5	**III**	Night of the 15th [first] part Mars 1 cubit above α Virginis		
NSA	194	LBAT 1057	Obv. 17	**IV**	Night of the 2nd first part Mars 2 cubits above α Virginis	n	n
GYT	147	69	Rev. 2	**VIII**	Night of the 16th first part Mars 2 cubits below β Capricorni		
NSA	194	LBAT 1057	Rev. 2	**IX**	Night of the[?] 2nd first part Mars […] below β Capricorni	n	n
GYT	154	73	Rev. 36'	**I**	[…Mars] 4 cubits [above] γ Geminorum		
NSA	201	LBAT **1059	Obv. 3	**I**	Night of the 9th first part Mars 4 cubits above γ Geminorum	n	n
GYT	154	73	Rev. 37'	**I**	[…] Mars 3 ½ cubits below α Geminorum		
NSA	201	LBAT **1059	Obv. 6	**I**	Night of the 28th first part Mars 3 ½ cubits below α Geminorum.	n	n
GYT	154	73	Rev. 37'	**I**	Night of the 21st first part Mars […]		
NSA	201	LBAT **1059	Obv. 10	**II**	Night of the 8th first part Mars 2 ½ cubits below β Geminorum	n	n
GYT	154	73	Rev. 38'	**II**	[…] Mars ½ cubit above δ Cancri		
NSA	201	LBAT **1059	Obv. 14	**III**	Night of the 2nd first part Mars ½ cubits above δ Cancri	n	n
GYT	154	73	Rev. 39'	**[VII]**	[Night of the xth] last part Mars 8 fingers below α Librae		
NSA	201	LBAT **1059	Rev. 42	**VIII**	Night of the 2nd last part Mars 8 fingers below α Librae.	n	n

	Year (SE)	Text				Month shift- Seen?	Expected?
GYT	154	73	Rev. 39'-40'	**[VII]**	Night of the 23rd last part Mars [… below β Librae]		
NSA	201	LBAT **1059	Rev. 42	**VIII**	Night of the 9th last part Mars 3 ½ cubits below β Librae	n	n
GYT	154	73	Rev. 40'	**[VIII]**	[Night of the xth last part Mars] 8 fingers below β Scorpii		
NSA	201	LBAT **1059	Rev. 44-46	**VIII**	Night of the 29th last part of the night Mars 8 fingers below β Scorpii.	n	n
GYT	154	73	Rev. 40'-41'	**[VIII]**	Night of the 23rd last part Mars [… above α Scorpii]		
NSA	201	LBAT **1059	Rev. 48	**IX**	Night of the 9th last part Mars 2 ½ cubits above α Scorpii.	n	n
GYT	154	73	Rev. 41'	**[IX]**	[Night of the xth last part Mars] ½ cubit [above θ] Ophiuchi		
NSA	201	LBAT **1059	Rev. 50	**IX**	Night of the 25th last part Mars ½ cubit above θ Ophiuchi	n	n
GYT	154	73	Rev. 41'	**XI**	Night of the 6th last part Mars 2 ½ cubits below β Capricorni		
NSA	201	LBAT **1059	Rev. 61	**XI**	Night of the 22nd last part Mars 2 ½ cubits below β Capricorni	n	n
GYT	154	73	Rev. 42'	**[XII]**	[Night of the x+]1st last part Mars ½ cubit above δ Capricorni		
NSA	201	LBAT **1059	Rev. 68	**XII**	Night of the 17th last part Mars ½ cubit above δ Capricorni	n	n
Diary	156	-155 A	Obv. 5	**IV**	Night of the 18th first part Mars 4 ½ cubits below θ Leonis		
NSA	203	LBAT 1060	Obv. 5	**III**	Night of the 30th first part Mars ⌜x¿ […] below θ Leonis	y	y

Appendix J: a summary of the remarks found in the Goal-Year Texts concerning intercalary months

Goal year	Jupiter (71)	Jupiter (83)	Venus (8)	Mercury (46)	Saturn (59)	Mars (79)	Mars (47)
79							"Year 31 Month XII_2, night of the 25th"
91			"Year 84 Month I, around the 4th"	"Month XII was intercalary"			"Year 45 Month I, night of the 3rd"
94						"Month XII was intercalary"	"Year 46 Month XII, night of the 24th"
95			"Month I, night of the 2nd"				
96			"Month XII was intercalary"				
97	"Month XII was intercalary"				"[Year 37], Month VI was intercalary"		
106	"Year 34: Month XII was intercalary"	"Month XII was intercalary"				"[Year 26: Month XII was] intercalary"	"[Year 58: Month XII was intercalary]"
107			"Month XII was intercalary" "Year 100, Month I, around the 1st"				
118	"Month XII was intercalary"	"Year 34 Month XII_2 night of the 22nd" "Year 36 Month I night of the 1st?"	"Month XII was intercalary"	"Month XII was intercalary"	"Year 58: Month XII was intercalary"		"Year 70, Month XII night of the 21st"
122	"Year 50, Month XII was intercalary."		"[Year 113, Month VI was inter]calary."	"[Year 75], Month VI was intercalary."			
124				"Year 77: Month XII was intercalary."			

Goal year	Jupiter (71)	Jupiter (83)	Venus (8)	Mercury (46)	Saturn (59)	Mars (79)	Mars (47)
129					"[Year 69, Month XII_2 …] (ideal) first on the 24th."		
131				"Month XII was intercalary"			
135	"Month XII was intercalary"						
139		"Month VI was intercalary"					
140		"[Year 56, Month VI] was intercalary."			"Year 80, Month XII_2 until the 25th"	"Month XII was intercalary"	
142			"[Year] 135, Month I night of the 2nd"		"Month XII [was intercalary]"		
155			"Year 148, Month I the 6th, "				
160		"Month XII was intercalary"	"Year 153 …"				
167		"Year 83, Month XII_2 night of the 15th"					
168				"Year 123 [Month I the xth …] (ideal) 1st on 26th of XII" alt: Year 123 Month I the 1st			
170		"Month XII was intercalary"					
171							"[Year 123] Month XII_2 night of the 24th"
175		"Year 91: Month XII			"[Year 115] Month XII_2,		

Goal year	Jupiter (71)	Jupiter (83)	Venus (8)	Mercury (46)	Saturn (59)	Mars (79)	Mars (47)
		was intercalary"			the 29th"		
177		"Month VI was intercalary"					
185				"[Year 138 …]"			
186			"Year 179 [Month I night of the x]+1st"				
194	"Month XII was intercalary"	"Year 110: [Month XII was intercalary.]"			"Year 134: Month XII was intercalary"	"Month XII was intercalary"	
202		"Year 118, Month XII_2 night of the $20th^?$"	"Year 195 Month I night of the $2nd^?$"		"[Year 1]42: Month XII was intercalary"		"Year 156 Month I night of the 12th"
205	"Month XII was intercalary"	"[Year 1]21, Month XII was intercalary"					
211						"Month VI was intercalary"	
236					"Year 178, Month I around the 6th"		
247							"[Year 1]99, Month XII [was intercalary]"

Appendix K: a summary of records of Mercury's Greek-letter phenomena from the non-mathematical texts

Appendix K1: Mercury phenomena from the Astronomical Diaries (ADART Vols. I-III)

Diary No.	Line	Record			Tropical longitude	Latitude
-463	Obv. 2'	V	[Around] the 19	(Mercury's) first appearance (in the east)	133.51	-0.524
-463	Obv. 7'	VI	Around 12 or 13	Mercury's [last] appearance in the east in Virgo	161.966	1.769
-418A	Obv.' 5	I	29	Mercury's last appearance in the west in Taurus.	44.585	1.515
-418A	Obv.' 18	IV	Around the 21	Mercury's first appearance in the west in Leo	119.21	1.459
-418A	'Rev. 5'	XII	29	Mercury's [first appearance] in the west [in Aries].	5.329	1.465
-418A	'Rev. 11'-12'	XII_2	Around the 23	Mercury's last appearance in the west in front of η Tauri.	24.871	2.229
-384	'Obv. 5'	IX	10	Mercury's [first appearance] in the east in Sagittarius [....]	237.392	3.165
-380B	'Obv.' 5'	X	20	Mercury's last appearance in the west in Capricorn	294.911	2.136
-378	'Obv.' 9'	VIII	22	Mercury's first appearance in the east in Sagittarius	249.378	-2.226
-375 B	'Obv. 10'	X	26-30	[.... Mercury's first appea]rance [in the west] 8 fingers above Jupiter, 4 fingers back to the west	307.739	-0.571
-375 B	Rev.' 3	XI	14	Mercury's last appearance in the west in Aquarius; I did not watch	285.33	1.009
-373 B	'Obv.' 10'	VII	27 or 28	Mercury's last appearance <in the east> in Scorpio	201.863	0.802
-373 B	'Rev.' 3'	XI	21-26	[.... Mer]cury's last appearance in the east in Aquarius	303.125	-1.959
-373 B	'Rev. 15'	XII	22-30	[....] Mercury's first appearance in the west in Aries [....]	358.227	-0.271
-372 A	Col. I 4	$I^?$	4	Mercury's [first appearance] in the west, 1 cubit 6 fingers above Jupiter	22.321	1.814
-372 C	'Rev.' 8'	IV	26	Mercury's first appearance in the west in Leo; (ideal) first appearance around the 19th.	129.955	0.912
-370	'Obv.' 1'-2'	IV	15	[.... Mercury's] last appearance [in the west] in Leo	132.699	-3.131
-366 A	Col. I 19'	I	Around the 22	Mercury's last appearance behind the Chariot	56.768	-0.95
-366 B	'Obv. 38'	$IV^?$	10	Mercury's first appearance in the west in Leo, 3 cubits in front of Venus to the west;...(ideal) first appearance on the 8th.	135.312	0.908
-346	Obv. 10	IX	21	Mercury's last appearance in the west in Capricorn	274.56	2.396
-346	Obv. 17	IX	29	[…] rising (of Mercury) to sunrise: 20°; (ideal) first appearance on the 29th of month IX	264.881	3.625
-346	Rev. 6	XI	[13]	[Mercury's] last appearance in [the ea]st in Aquarius	300.156	-2.006
-346	Rev. 25-26	XII	$[17^?]$	26 Mercury's first appearance in the west in Aries; sunset to setting of Mercury: 14°.	4.684	0.926
-343	'Rev.' 19'	XII	21	[.... Mercury's first appearance in the west in Pisces ....] (ideal) first appearance [on] the 21st.	326.398	-1.136

Diary No.	Line	Record			Tropical longitude	Latitude
-332 A	Obv.' 5	V	10	Mercury's [last appearance] in the west in Virgo	157.479	-3.343
-329 B	'Rev. 3'	XII_2	1 to 4	Mercury's first appearance in the east in Pisces [....]	332.699	-2.512
-328	Obv.' 8	V	21	Mercury's [first] appearance in the west, omitted [....]	179.596	-1.516
-328	Obv.' 27	VII	4	Mercury's first appearance in the east in Libra	184.224	1.97
-328	'Rev. 3'	VIII	1 to 4	[Mercury's] last appearance in the east in Scorpius	218.116	0.39
-324 B	'Obv. 16'	III	3	Mercury's first appearance in the west in Cancer;	80.839	1.867
-324 B	Rev.' 5	IV	15	Mercury's last appearance in the west in Leo.	133.705	-3.105
-322 A	'Obv.' 11'	I?	22-30	[.... Mer]cury's [first appearance] in the west in Gemini [....]	49.202	1.536
-322 D	Obv. 24	X	4	Mercury's first appearance in the west in Aquarius,	298.627	-1.128
-322 D	Obv. 35	X	23	Mercury's last appearance in the west in Aquarius	314.659	3.239
-322 D	Rev. 2	XI	11	Mercury's first appearance in the east in Aquarius	301.482	2.149
-322 D	Rev. 25	XII	[12]	Mercury's last appearance in the east in Pisces	327.876	-2.424
-321	Obv.' 11	I	20	Mercury's first appearance in the west in "Bull of Heaven"	39.265	1.609
-321	'Rev. 17'	VI	8	Mercury's first appearance in the east (error for: west) in Virgo (error for: Libra);	182.433	-2.28
-309	'Rev. 3'	VIII	21	Mercury's [last appearance] in the east [in Sagittarius?]	236.667	-0.46
-308	Obv.' 11	I	[19?]	[Mer]cury's first appearance in the west in "Bull of Heaven"; ... (ideal) first appearance on the 16th?.	48.102	1.986
-308	Rev. 8'	VI	3	Mercury's first appearance in the west in Libra; ... (ideal) first appearance on the 1st	182.725	-2.099
-308	Rev. 10'	VI	11?	Mercury's last appearance in the west in Libra	191.188	-2.9
-307 B	Line 3'	IV	7	[last appearance] of Mercury in the east in Gemini; [omitted. ....]	85.95	0.911
-294	'Obv.' 8'	II	6	Mer[cury's last appearance in the west in Gemini ....]	64.093	0.789
-291 A	'Obv.' 3'	I	25?	Mercury's first appearance in the east, omitted	6.992	-3.169
-291 B	'Obv. 6'	II	17	[Mercury's last appearance in the east, omitted.]	40.889	-0.518
-291 B	'Obv. 15'	III	[8]	[Mercu]ry's first appearance in the west in Gemini	82.452	1.909
-291 B	Rev.' 7	IV	22	Mercury's last appearance [in the wes]t in Leo.	132.385	-3.879
-291 B	Rev.' 17	V	15-16	[Mercu]ry's first appearance in the east in Leo.	118.839	-1.384
-289	'Obv. 19'	III	12	Mercury's last appearance in the west in Cancer	94.367	-3.792
-289	Rev.' 4	IV	7	Mer[cury's] first appearance in the east in Cancer... [(ideal) first appearance] on the 5th	87.127	-1.901
-288	Obv.' 5	VII	17	Mercury's first appearance in the east in Libra	176.124	1.554
-288	'Rev. 6'	XII_2	16	[.... Mercury's first appearance in the west in Aries, ...] (ideal) first appearance on the 13th	22.672	1.293

Diary No.	Line	Record			Tropical longitude	Latitude
-284	Obv.' 7'	VII	15	[Mercury's] first appearance [in the west ....], omitted.	227.637	-2.576
-284	Obv. 13'	VII	Around the 25	Mercury's last appearance in the west .... was omitted	233.012	-1.478
-284	Obv. 24'	VIII	[14?]	Mercury's first appearance? in the east in Scorpius, 3 ½ cubits above a	216.835	2.891
-284	'Rev.' 16'	X	[25 - 27]	Mercury's [first appearance] in the west [....]	318.043	-0.774
-284	'Rev.' 28'	XI	18	Mercury's last appearance in the west in Pisces	340.424	3.551
-283 A	Obv. 4	VII	27	Mercury's last appearance in the west omitted [....]	211.822	-0.366
-281 B	Rev.' 1	X	3	Mercury's [last appearance] in the west in Capricorn	287.751	2.914
-281 B	Rev.' 6	X	[15-16]	[.... Mercury's] first appearance [in the east in Capricorn]	275.718	3.259
-278 B	'Rev.' 9'	XI	11	Mercury's first appearance in the west in Aquarius [....]	325.634	-0.63
-277 A	Obv. 2	I	4?	Mercury's] first appearance [in the east,] omitted	341.526	-1.919
-277 A	Rev. 4	V	7	Mercury's [first appearance] in the east [in Cancer]	105.342	-1.645
-277 A	Rev. 10	V	28	Mercury's [last appearance] in the east in Leo [....]	134.552	1.829
-277 A	Rev. 27-28	VII	20	Mercury's first appearance in the west, omitted.	215.944	-2.576
-276	'Rev.' 1'	X	26	Mercury's [last appearance] in Aquar[ius ....]	313.039	3.769
-276	'Rev.' 4'	XI	12	Mercury's first appearance in the east in Aquarius	302.344	1.47
-273 B	Obv.' 20	VIII	[21]	Mercury's] first appearance [in the west] in Sagittarius... (ideal) first appearance on the 19th	258.619	-1.964
-270 B	Obv.' 2	VII	2	Mercury's first appearance in the west, omitted.	210.092	-2.616
-270 B	'Rev. 9'	XII?	[26-30]	[.... Mercury's] last appearance in the east in Pisces	336.279	-2.562
-266 B	'Obv.' 16'	IX	1	Mercury's last appearance in the west in Sagittarius [....]	252.331	-2.111
-266 B	'Rev.' 6'	XII_2	Around the 10	Mercury's [last appearance] in the west in Aries	11.898	2.897
-264	Rev.' 4-5	VII	25	[.... Mercury's] last appearance in the west ...., omitted.	226.633	-2.537
-261 B	'Obv.' 9'	IX	20	Mercury's first appearance in the west in Capricorn; ...(ideal) first appearance on the 19th or 18th.	274.119	-1.679
-260	'Rev. 7'	VI	Around the 22	Mercury's [last appearance] in the east in the beginning of Libra	177.801	1.599
-257 A	'Obv.' 7'	II	4	Mercury's first appearance in the west in Gemini.	62.372	1.732
-256	'Obv.' 15'	III	[11-13]	[.... Mercury's] last appearance in the west in Cancer.	93.775	-2.753
-256	'Rev.' 7'	XI	1	Mercury's [last appearance] in the west [in Aquarius; ....]	310.603	3.371
-256	'Rev.' 11'	XI	16?	Mercury's] first appearance [in the ea]st in Aquarius.	298.076	2.437
-255 A	Obv.' 12	I	27	, Mercury's first appearance in the west in Taurus	40.352	1.802
-255 B	UE 1	VI	2	Mercury's [first appearance] in the west [in Virgo;] [....]	164.543	-0.724

Diary No.	Line	Record			Tropical longitude	Latitude
-255 A	'Rev. 14'	VI_2	Around the 18	Mercury's first appearance in the east in the beginning of Libra	174.925	1.139
-254	'Obv. 11'	IX	Around the 20	Mercury's last appearance in the west in Capricorn;	277.041	2.32
-254	'Obv. 12'	IX	Around the 29	Mercury's first appearance in the east in the end of Sagittarius;	266.45	3.617
-254	Rev.' 17	XI	13	Mercury's last appearance in the east in Aquarius	303.134	-2.05
-253 A	Obv.' 2-3	VII	3	Mercury's [last appearance] in the ea[st in Virgo;	171.874	1.662
-253 A	'Rev. 4'	XII_2	[$9^?$]	[.... Mer]cury's last appearance in the west in the end of Aries	14.366	2.477
-251	Obv.' 3	VII	11	Mercury's first appearance in the west, omitted	217.54	-2.439
-251	Obv.' 6	VII	26	Mercury's last appearance in the west, omitted.	231.326	-2.019
-251	Obv.' 12	VIII	13	Mercury's first appearance in the east in Scorpius	216.695	2.583
-251	'Rev. 12'	XII	20	Mercury's] first appearance [in the east in Pisces].	329.084	-1.353
-249 B	'Obv.' 3'	IX	Around the 20	Mercury's] first appearance in the west in Capricorn	289.447	-1.399
-249 B	'Obv.' 12'	X	Around the 11	[Mercury's] last appearance in the west in Aquarius	302.507	3.428
-249 B	'Rev.' 18'	XII	Around the 4	Mercury's last appearance in the east in Pisces	326.919	-2.346
-248	'Obv.' 1'	I		[.... Mercury's first appearance in the west in ....,] (ideal) first appearance on the 6th	29.883	1.421
-247 C	Obv. 8'	X	Around the 9	Mercury's first appearance in the east in Sagittarius	259.299	3.541
-246	Obv.' 13	II	5	Mercury's first appearance in the east, omitted	30.453	-2.846
-246	'Rev. 10'	VI	12	Mercury's [last appearance] in the ea[st in Virgo ....]	162.507	1.831
-245 B	'Obv. 2'	III	Around the 6	Mer[cury's first appearance in the west in Gemini ....]	81.118	1.875
-241	Line 5'	II	Around the 28	Mercury's first appearance in the east in Gemini, 1 cubit behind Jupiter, [omitted ....]	57.898	-2.232
-240	Rev.' 12	XI	[4]	[.... Mercury's] last appearance [in the east in Capri]corn.	292.92	-1.911
-237	'Obv. 7'	III	Around the 20	Mercury's last appearance in the west in Cancer	107.713	-2.402
-237	Rev.' 3	IV	[23]	[Mercury's first appearance in the east in Cancer.;]... (ideal) first appearance on the 21st.	99.235	-0.985
-237	Rev.' 9	V	Around the 10	Mercury's last appearance in the east in Leo	124.139	1.715
-234 A	Obv.' 6	VII	17	Mercury's last appearance in the east in Libra	186.502	1.313
-234 A	Obv.' 26	IX	7	Mercury's [first appearance] in the west in Scorpius [....]	262.911	-1.985
-234 A	Obv.' 35	IX	Around the $22^?$	Mercury's [last appearance in the west in ....]	275.076	0.96
-234 A	'Rev. 7'	XI	Around the 17	Mercury's last appearance in the east in Aquarius	296.723	-1.902
-234 A	'Rev. 17'	XII	Around the 22	Mercury's [first appearance in the west in ....]	0.488	0.613
-234 A	'Rev. 34'	XII_2	Around the 23	Mer[cury's last appearance in the west in Taurus ....]	28.952	1.695

Diary No.	Line	Record			Tropical longitude	Latitude
-232	Obv. 14	VIII	9	Mercury's first appearance in the east (error for west) in Sagittarius	243.3	-1.261
-232	Obv. 16	VIII	14	Mercury's last appearance in the west in Sagittarius; from its first to its last appearance, when I watched, I did not see it.	241.339	0.149
-232	Obv. 21-22	VIII	28	Mer[cury's] first appearance [in the east in Scorpius, ...] … (ideal) first appearance on the 26th.	227.113	3.053
-232	Rev. 3	X	8	Mercury's [last appearance in] the east in Capricorn;	271.163	-1.483
-232	Rev. 17	XI	Around the 14?	Mercury's first appearance in the west in the [beginn]ing of Aquarius	333.723	0.098
-230 A	Obv.' 10-11	I	24	Mercury's first appearance [in the west in (the beginning of) Gemini,]	58.529	1.897
-230 A	'Rev. 10'	VI	Around the 12	Mercury's first appearance in the west, om[itted]	198.499	-2.354
-230 A	'Rev. 8'	VI	26	Mercury's [last appearance] in the west, [omitted ....]	211.021	-2.858
-226 A	'Obv. 11'	II	[13]	Mercury's] first appearance [in the east, ...] omitted.	26.644	-2.833
-226 A	Rev.' 10	III	19	Mercury's first appearance [in the west in Can]cer	95.21	1.872
-225	Obv. 10	III	26	Mercury's last appearance in the west in Leo	128.988	-3.568
-225	Rev. 12-13	IV	21	Mercury's first appearance in the east in the beginning of Leo	115.675	-1.53
-222	Rev. 4'	X	Around the 10	Mercury's first appearance in the east in Capricorn	280.07	3.376
-221	Obv. 2-3	IX	4	Mercury's [first appearance in the west] [in (the beginning of) Capricorn ....]	265.72	-1.916
-218	'Obv.' 5'	VII	Around the 17	Mercury's first appearance in the west ...., omitted;	219.381	-2.567
-218	'Obv.' 5'	VII	25	Mercury's last appearance in the west ...., [omitted ....]	227.512	-2.538
-218	'Obv.' 14'	VIII	21	Mercury's first appearance in the east in Scorpius	213.79	2.83
-214	UE 1	IX	12	Mercury's first appearance in the east in Sagittarius [....]	255.912	3.398
-212 A	'Obv. 11'	X	17	Mercury's last appearance in the east in Capricorn;	271.293	-1.585
-211 A	Obv.' 8	VI	[25]	[.... Mercury's] first appearance in the west, omitted.	210.94	-2.487
-211 B	'Rev.' 3'	XI	4 or 5	Mercury's [last appearance in the west in Pisces ....]	329.675	3.421
-210	'Obv.' 6'	III	12?	Mercury's [last appearance in the west in Cancer ....]	94.477	-3.205
-209 D	'Obv. 19'	III	4	[.... Mercu]ry's last appearance in the west in Gemini	75.107	-1.958
-209 D	Rev.' 5	IV	9	Mercury's first appearance in the east in Gemini;...; (ideal) first appearance on the 5th	75.895	-1.201
-209 D	Rev.' 9	IV	23	Mercury's last appearance in the east in Cancer	100.725	1.379
-209 D	Rev.' 23	VI	5	Mercury's first appearance in the west in Virgo; ... (ideal) first appearance on the 3rd	170.76	-1.238
-207 A	Obv.' 16	I	20?	Mercury's last appearance in the west in Taurus	33.955	0.342
-207 A	Obv.' 31	II	19	Mercury's first appearance in the east ...., omitted;	32.75	-3.454
-207 A	Obv.' 34	III	5	Mercury's last appearance in the east omitted	53.152	-1.001

Diary No.	Line	Record			Tropical longitude	Latitude
-204 C	Rev. 10	I	Around the 9	Mercury's last appearance in the east in Aries?	350.663	-2.716
-203	Obv. 4	VIII	8	Mercury's last appearance in the east in Scorpius	223.687	0.035
-202 B	'Obv.' 9'	VII	Around the 28	Mercury's [last appearance] in the east in Libra	203.497	0.805
-202 B	'Rev.' 4'	XI	Around the 20+[x]	Mercury's] last? appearance [in the ea]st in the end of Aquarius	300.25	-1.739
-201 B	Rev. 5-6	X	13	Mercury's first appearance in the east in Sagittarius;... (ideal) first appearance on the 8th	258.1	3.282
-199 A	'Rev.' 6'	V	15	Mercury's first appearance in the east in Leo	121.675	-0.556
-197 B	Obv.' 6	VII	19	Mercury's first appearance in the east in Libra, ...(ideal) first appearance on the 17th.	194.263	2.014
-197 B	Obv.' 19	VIII	27	Mercury's [last appearance] in the east in [Sagittarius ....]	236.549	-0.5
-197 B	'Rev. 6'	XI	14	Mercury's first appearance in the east in Aquarius	301.613	1.653
-197 B	'Rev. 19'-20'	XII	13	Mercury's last appearance in the east in Pisces	327.207	-2.391
-195 D	Obv. 1-2	IX	16	Mercury's [last appearance] in the west [in Capricorn ....]	279.731	2.724
-195 D	Obv. 9	IX	Around the 24	Mercury's first appearance in the east in Capricorn	270.215	3.635
-195 E	Obv. 9-10	XII	13	Mercury's first appearance in the west in Aries...(ideal) first appearance on the 11th.	13.525	1.333
-194 A	'Obv.' 4'	II	Around the 16	Mercury's [first appearance] in [the east, ... omitted; ....]	36.63	-3.325
-194 A	'Obv.' 7'	III	2 or 3	[.... M]ercury's last appearance in the east, ... omitted	57.966	-0.673
-193 A	LE 1	II	14	Mercury's first appearance in the east, [omitted ....]	23.187	-3.001
-193 A	'Rev. 5'	II	2[8?]	[Mercu]ry's last appearance in the east, omitted	45.705	-0.809
-193 B	'Obv.' 28'	VIII		[.... Mercury's first appearance in the west in Sagittarius;] ... (ideal) first appearance on the 20th	245.583	-2.198
-193 B	'Obv.' 28'	VIII	Around the 29	Mercury's last appearance in the west in Sagittarius	251.016	-0.738
-193 D	'Obv.' 15'	X	[28 or 29]	[.... Mercury's] last appearance [in the east in Cap]ricorn;	279.206	-1.659
-193 D	'Rev. 17'	XII	[2 or 3]	Mercury's [first appearance] in the west in Pisces[....]	339.141	0.093
-192 A	Obv. 2-4	II	18	Mercury's first [appearance] in the west in Gemini;… (ideal) first appearance on the 16th.	81.298	1.949
-191 A	Line 3'	IV	Around the 22	Mercury's [first appearance] in the [east in Cancer ....]	99.294	-1.295
-191 B	Obv. 6	VIII	[5-8]	Mercury's first appearance in the east in the end of Libra	203.396	2.381
-190 B	'Obv.' 3'	II	Around the 6	Mercury's first appearance in the west in the end of Taurus	45.648	1.546
-190 B	'Obv.' 19'	III	16	Mercury's last appearance in the west in the beginning of Cancer	89.886	-2.441
-190 B	'Rev.' 5'	IV	Around the 17	[Mercury's first appearance in the east in Gemini ....]	82.863	-1.931

Diary No.	Line	Record			Tropical longitude	Latitude
-190 E	Line 5'	XII	27	Mercury's last appearance in the east in Pisces [....]	327.182	-2.371
-189 A	'Obv.' 11'	II	Around the 8	Mercury's last appearance in the west in Gemini	70.266	-1.063
-189 B	'Obv.' 6'	VI		[.... Mercury's first appearance in the east in Virgo; ....] (ideal) first appearance on the 24th;	171.859	0.976
-188	Obv. 4-5	I	1	Mercury's first appearance in the west in the beginning of Taurus;…	25.039	1.733
-187 A	Obv.' 16	VIII	3	Mercury's first appearace in the west in Sagittarius,	251.106	-2.183
-187 A	'Rev. 2'	XI	Around the 15	Mercury's [first appearance in] the west in [Pisces; ....]	344.934	0.046
-186 C	Obv. 15-16	XI	14	Mercury's first appearance in the west in [Virgo,]...(ideal) first appearance on the 12th.	336.188	0.279
-186 A	'Rev. 5'	XII	1	Mercury's [last appearance] in the west in Pisces alt: the end of Pisces	353.137	3.408
-183 C	Rev.' 1	IV	[1 or 2]	Mercury's first appearance in the east in Gemini ....] (ideal) first appearance on the 26th of month III .... [....]	80.42	-1.149
-182 A	'Obv.' 13'	II	23	Mercury's last appearance in the west in Gemini	59.777	-2.191
-182 A	'Rev.' 12'	VIII	4?	Mercury's [last appearance] in the east [in Libra	197.265	1.062
-182 A	'Rev.' 38'	X	17	Mercury's first appearance in the east in Capricorn	277.018	3.605
-180 D	Rev. 9-10	XI	8	Mercury's [first appearance in the west in Pisces]	303.582	-2.034
-178 A	Obv.' 9	V	[10 or 11]	[.... Mercury's] last appearance [in the east] in Leo	135.297	1.817
-178 B	UE 1'	VII	Around the 2	Mercury's first appearance in the west, ... omitted.	213.731	-2.687
-178 C	Obv.' 9	XI	[11]	Mercury's last appearance in the west in P[isces?];	325.106	3.795
-178 C	'Rev. 13'	XII	29	Mercury's last appearance in the east in the end of Pisces	345.391	-2.531
-175 B	Obv.' 3	IX	1	Mercury's first appearance in the west in the end of Sagittarius	263.504	-2.054
-173 A	Obv.' 16	VIII	1	Mercury's first appearance in the west in Sagittarius	245.382	-1.866
-173 A	'Rev. 5'	XII	3	Mercury's last appearance in the west in Aries	355.272	3.447
-171 B	Obv.' 3	V	18	Mercury's last appearance in the east in the beginning of Leo	123.358	1.724
-171 A	'Rev.' 6'	XII_2	16	Mercury's last appearance in the east in Aries	349.3	-2.213
-170 C	'Rev. 3'-5'	III	24	Mercury's first appearance in the east in Gemini ... (ideal) first appearance on the 22nd;	78.904	-1.997
-170 E	Obv. 7-10	VII	7	Mercury's first appearance [in the east] in Libra	183.478	1.619
-168 A	Obv.' 12	V	27	Mercury's first appearance in the west[sic] in Virgo; ... (ideal) first appearance on the 25th	151.677	0.279
-168 A	Obv.' 25	VI	[23	Mercury's] last appearance in the east in (the beginning of) Libra	184.07	1.354
-168 A	Rev. 10'-11'	VIII	Around the 15?	Mercury's first appearance in the west in Sagittarius;	262.936	-1.9

Diary No.	Line	Record			Tropical longitude	Latitude
-168 E	Obv.' 2-3	IX	Around the 2	Mercury's [last appearance] in the west [in Capricorn.	270.166	1.764
-165 A	'Rev. 5'	V	Around the 1	Mercury's last appearance in the east in Leo	128.784	1.743
-164 B	'Obv.' 9	VII	22	Mercury's first appearance in the east in Libra;... (ideal) first appearance on the 20th;	192.932	1.852
-164 B	'Rev.' 17'	XII	6?	Mercury's last appearance in the east? in ....;	311.896	-1.548
-163 B	Obv.' 15	VIII	Around the 18	Me[rcury's last appearance in the east in Scorpius ....]	211.431	0.588
-163 C	Rev.' 4	XI	10	[first appearance] in the east in Capricorn	282.544	2.616
-163 C	'Rev.' 3'	XII	Around the 14	Mercury's [last appearance in the east in Aquarius ....] [the end of]	316.127	-2.213
-162	Obv. 14-15	V	16	Mercury's last appearance in the west [in Virg]o?: from the 14th on, when I watched I did not see it.	174.407	-3.211
-161 A	'Obv.' 11'	I	Around the 18	Mercur[y's last appearance in the west in Taurus ....]	35.616	0.635
-161 B	'Obv.' 21'-22'	II	Around the 19	Mercury's [first appearance] in the east, [omitted ....]	34.543	-3.374
-161 B	'Rev.' 7'	V	Around the 15	Mercury's last appearance in the west in Virgo	159.852	-3.715
-161 A	'Rev.' 10'	VI	Around the 7	Mercury's first appearance in the east in the end of Leo; .... [....]	145.058	-0.351
-160 C	'Obv.' 2'	XI	Around the 4	Mercury's first appearance in the west in Pisces	336.767	-0.06
-158 B	'Rev. 5'	V	[Around the 15]	Mercury's last appearance in the east in Leo	128.213	1.787
-158 C	Line 10'	VII	5	Mercury's first appearance in the west ...., omitted;	205.744	-2.479
-157 A	Obv. 5-6	IV	5	[Mercury's] last appearance [in the east] in Cancer	104.809	1.253
-156 A	'Obv.' 17'	I	Around the 2	Mercury's first appearance in the west in Taurus	24.962	0.898
-155 A	Obv. 14	IV	24	Mercury's [first appearance] in the west in Leo	128.964	1.131
-154 B	LE 2-4	XI	21	Mercury's first appearance in the west in the end <of Aquarius>;... (ideal) first appearance on the 18th	348.251	0.487
-153	'Rev.' 3'	V	[Around] the 10	Mercury's first appearance in the east in Leo;	122.326	-2.137
-149 A	Obv.' 3'	III	10	Mercury's [last appearance] in the east in Gemini [....]	82.407	0.62
-149 B	'Rev. 5'-6'	VII	Around the 7	Mercury's last appearance in the east in Libra;	196.86	1.033
-148	Line 8'	IX	22	Mercury's first appearance in the east in Sagittarius	252.255	3.281
-146	'Obv. 2'	IX	Around the 19	Mercury's [last appearance] in the east [in Sagittarius ....]	261.017	-1.114
-146	Rev.' 5	X	25	Mercury's first appearance in the west in the beginning of Pisces .... [....]	323.7	-0.488
-144	'Obv. 33'	VII	Around the 27	Mercury's [first appearance] in the east in Libra	189.873	1.257
-144	Rev.' 23	IX	Around the 1	Mercury's last appearance in the east in Scorpius	222.392	0.316
-143 A	Line 23'	V	3	Mercury's first appearance in the west in Virgo	157.041	-0.132
-143 A	Line 30'	V	18	Mercury's last appearance in the west in Virgo	176.937	-2.116

Diary No.	Line	Record			Tropical longitude	Latitude
-143 B	Rev.' 5	VI	Around the 24	Mercury's first appearance in the east in Virgo	172.967	0.947
-141 A	'Obv.' 7'	I	Around the 23	Mercury's last appearance in the west in Taurus	30.337	1.022
-141 A	'Obv.' 16'	II	Around the 28	Mercury's first appearance in the east .... omitted [....]	32.604	-3.106
-141 D	'Obv.' 13'	VI_2	Around the 8	, Mercury's [last appearance] in the west[sic] in Virgo [east]	168.34	1.761
-141 F	'Obv.' 31'	VIII	Around the 17	Mercury's last appearance in the west in Sagittarius	260.908	0.337
-141 F	'Rev. 24'	XII	Around the 11	Mercury's last appearance in the west in Aries	12.336	3.011
-140 A	Obv.' 15	I	Around the 25	Mercury's [first appearance in the east ...., omitted ....]	7.663	-3.285
-140 C	'Rev. 27'	X	Around the 8	Mercury's last appearance in the east in Capricorn	274.111	-1.55
-140 D	Rev.' 7-8	XI	14	Me]rcury's first appearance in the west in Pisces;... (ideal) first appearance on the 10th	338.606	0.464
-137 A	'Obv.' 11'	II	Around the 24	Mercury's last appearance in the west in Gemini	82.911	-1.697
-137 C	'Rev. 2'	VIII	Around the 12	Mercury's [last appearance in the east in Scorpius ....]	218.25	0.323
-137 D	'Obv. 5'	IX	[27]	Mercury's] first appearance in the west in Capricorn; .. (ideal) first appearance on the 25th	290.532	-1.237
-137 D	Rev.' 12-13	X	[Around the 17]	[Mercu]ry's last appearance in the west in Aquarius	300.241	3.336
-137 D	Rev.' 29	XI	Around the 2	Mercury's first appearance in the east in the end of Capricorn;	288.171	2.633
-136 A	'Obv. 8'	VII	6	Mercury's first appearance in the east in Virgo;	166.014	1.132
-136 C	'Obv.' 7'	X	10	last appearance of Mercury in the west in Capricorn: [from] the 7th, when I watched I did not see it.	286.624	1.383
-136 C	'Obv.' 13'	X		[.... Mercury's ....] (ideal) first appearance on the 21st	274.002	3.647
-134 B	'Rev. 4'	XI	26	Mercury's first appearance in the west in Pisces [....]	339.024	-0.187
-133 A	'Obv. 6'	VI	[10 to 13]	Mercury's] last appearance in the east in Leo.	141.949	1.86
-133 B	'Obv. 12'	XI	21	Mercury's first appearance in the west in the beginning of Pisces;..., (ideal) first appearance on the 20th.	326.704	-0.363
-133 B	Rev.' 15	XII	Around the 16	Mercury's last appearance in the west in the end of Pisces;	345.038	3.597
-132 A	'Obv.' 13'	II		Mercury's first appearance in the west in Gemini;… [(ideal) first appearance] on the 5th [....]	63.255	1.734
-132 B	Obv. 31	VII	2	Mercury's first appearance in the west ...., omitted	215.613	-2.716
-132 B	Rev. 17	VII	14 or 5	Mer[cury's last appearance in the west ....,] omitted	222.862	-2.104
-132 B	Rev. 17	VII	Around the 29	Mercury's [first appearance in] the east in Scor[pius	208.03	2.19
-132 D	'Obv.' 17'	IX	Around the 13	Mercury's last appearance in the east in Sagittarius	254.354	-1.156
-132 D	'Rev' 12'	X	Around the 14	Mercury's first appearance in the west in Aquarius	307.184	-1.191

Diary No.	Line	Record			Tropical longitude	Latitude
-132 D	'Rev.' 26'	XII	29	last appearance of Mercury in the east in Pisces: from the 25th, when I watched I did not see it	347.722	-2.506
-131 B	Obv. 2-4	XI	22	Mercury's first appearance in the east in Aquarius;...; (ideal) first appearance on the 19th	298.232	1.496
-130 D	Rev.' 17	XII	23	Mercury's [....] in the west in Aries	23.065	1.336
-129 A	'Obv.' 4'	I	Around the 26	Mercury's last appearance in the west in the end of Taurus	54.48	0.052
-129 A	'Rev.' 7'	IV	14	Mercury's first appearance in the west in Leo	131.137	1.176
-129	'Rev.' 8'	V	Around the 22	Mercury's last appearance in the west in Virgo	174.462	-3.55
-126 A	'Obv. 4'	VIII	Around the 13	Mercury's first appearance in the east in Scorpius	218.874	2.225
-125 A	Obv.' 12	I	Around the 12	[Mercury's last appearance in the west in Pisces	351.726	-2.676
-125 A	Obv.' 6	I	16	last appearance of Mercury in the east in Aries: from the 12th on, when I watched I did not see it	358.621	-2.447
-125 A	'Rev.' 4'	V	Around the 17	Mercury's [last appearance in] the east [in Leo	123.998	1.72
-124 A	'Obv.' 22'	II	22	Mercury's last appearance in the west in the beginning of Cancer	85.804	-2.37
-124 A	'Obv.' 33'	III	Around the 22	Mercury's [first appearance in the east in Gemini ....]	78.934	-2.282
-124 A	'Rev.' 25'	VI	1	Mercury's [first appearance] in the west in Libra	188.167	-2.266
-124 A	'Rev.' 17'	VI	10	Mercury's last appearance in the [west in Libra; ....]	197.083	-3.049
-124 B	'Obv.' 18'	IX	Around the 21	Mercury's first appearance in the west in Capricorn	288.641	-1.526
-124 B	'Rev.' 11'	X	2	Mercury's last appearance in the west in Aquarius	302.535	0.316
-124 B	'Rev.' 7'	X	Around the 28?	Mercury's first appearance in the east in the end of Capricorn	290.93	2.535
-124 B	'Rev.' 21'	XI	2	Mercury's first appearance in the east in the end of Capricorn	291.029	1.662
-123 A	'Obv. 11'	III	19	Mercury's first appearance in the east in Gemini;... (ideal) first appearance on the 16th [....]	65.351	-2.063
-123 C	Line 11'	V	Around the 10	Mercury's [first appearance in the west in Virgo ....]	153.911	-0.078
-122 A	'Obv.' 10'	II	Around the 4	Mercury's last appearance in the west in Taurus	46.136	0.859
-122 C	'Obv. 10'	III	[24]	[.... Mercury's] first appearance in [.... to the ea]st;... (ideal) first appearance on the 23rd	66.543	-0.236
-122 C	'Obv.' 11'	III	[25]	[.... Mercury's] last appearance [in the east] in Gemini;	68.472	-0.039
-122 D	'Rev.' 9'	VI_2	Around the 21	Mercury's last appearance in the east in Libra	181.461	1.543
-121	'Obv. 4'	III	Around the 17	Mercury's [first appearance] in the west in Cancer [....]	104.993	1.767
-120	'Obv.' 4'	IV	Around the 19	Mercury's last appearance in the west in Leo	133.682	-3.211
-119 C	'Obv. 10'	II	Around the 3	Mercury's first appearance in the west in Gemini [....]	68.289	1.85

Diary No.	Line	Record			Tropical longitude	Latitude
-119 C	'Obv. 19'	III	20	Mercury's last appearance in the west,	114.858	-4.167
-118 A	Obv.' 15	I	30	Mercury's first appearance in the west [in the beginn]ing of Gemini, … (ideal) first appearance [on the 27th in the end of Taur]us.	56.372	1.86
-118 A	'Rev. 17'	VII	Around the 1	Mercury's [last appearance] in the west, ... [omitted?]	209.035	-2.953
-118 A	'Rev. 9'	VII	21	Mercury's [first appearance] in the east in Libra	194.063	1.833
-117 B	'Rev.' 13'	XII	[14]	[.... Mercu]ry's last appearance in the east in the end of Aquarius.	318.412	-2.244
-112	Obv.' 3	VII	1 to 8	[.... Mercury's ....] first appearance in the west ...., omitted	205.293	-2.39
-111 A	Obv.' 6	I	10	Mercury's first appearance [in the west in] Taurus;... [(ideal) first appearance on the 8th ....]	49.902	1.791
-111 B	'Obv.' 4'	II	Around the 15	Mercury's [last appearance] in the west in the beginning of Ca[ncer ....]	89.071	-1.471
-110	'Rev.' 12'	V	Around the 4	Mercury's first appearance in the west in Virgo	153.586	0.091
-110	'Rev.' 12'	V	Around the 27	Mercury's [last appearance in the west in the end of Virgo ....]	182.131	-2.88
-109 A	'Obv.' 18'	IX	[9 to 13]	[.... Mercury's] first appearance [in the west ....], ... (ideal) first appearance on the 7th in Sagittarius	263.738	-1.995
-108 A	'Obv.' 18'	II	Around the 5	Mercury's first appearance in the east ...., omitted.	35.436	-2.639
-108 A	'Obv.' 36'	III	12	Mercury's [first appearance in the west in Cancer ....]	104.19	1.804
-108 A	'Rev.' 12'	IV	Around the 21	Mercury's last appearance in the west in the beginning of Virgo	153.235	-3.349
-108 A	'Rev.' 16'	V		[.... Mercury's] first appearance [in the east in] Leo; ... (ideal) first appearance on the 15th.	139.606	-1.044
-107 A	Obv.' 6	IV	Around the 18	Mercury's last appearance in the west in Leo	136.777	-3.623
-105 A	'Obv.' 8'	I	[Around the 24]	Mercury's first] appearance [in the west in Gemini	57.424	1.819
-105	'Obv.' A35', B32'	III	Around the 5 or 6	Mercury's last appearance in the west in Cancer	100.263	-2.785
-105 A	'Obv.' 48'	IV	5	Mercury's first appearance in the east in Cancer,	92.282	-1.51
-105 A	'Rev. 27'	VI	[Around the 3]	Mercury's first appearance in the west ...., omitted.]	184.794	-1.188
-105 A	'Rev. 35'	VI	Around the 2[6]	[Mercury's] last appearance in the west ....,	210.734	-2.949
-105 A	'Rev. 45'	VII	Around the 17	Mercury's first appearance in the east in Libra	197.041	1.783
-103 A	Line 12'	II	Around the 17	Mercury's last appearance in the west in Gemini	61.005	-0.038
-103 B	'Obv.' 1'	VIII	[1]7	Mercury's [first appearance] in the west in [Sagittarius ....]	260.421	-2.155
-99 A	Line 11'	VIII	2	Mercury's first appearance in the east in the end of Libra	206.833	2.021
-99 B	Line 6'	IX	10	Mercury's last appearance in the east in Sagittarius	244.639	-0.577

Diary No.	Line	Record			Tropical longitude	Latitude
-98 C	Obv. 14-15	X	12	Mercury's first appearance in the west in Capricorn	291.083	-1.576
-98 C	Obv. 17	X	Around the 27	Mercury's last appearance in the west in Aquarius	310.309	1.466
-97 C	Rev. 11	II	Around the 6	Mercury's last appearance in the west in Gemini	72.564	-1.011
-97	Rev.' 4	V	3	Mercury's first appearance in the west in Virgo	159.228	-0.249
-96 A	Line 14'	II	Around the 1	Mercury's [last appearance] in the west in the end of Taurus [....]	51.638	-0.565
-95 D	Line 6'	II	28	Mercury's [first appearance] in the east [...., omitted ....]	33.436	-3.13
-95 E	Line 10'	V	20	Mercury's last appearance in the west in Virgo: from the 18th, when I watched I did not see it	156.636	-3.764
-95 C	'Rev.' 3'	VI	16	Mercury's first appearance in the east in the end of Leo	142.337	0.352
-94	Line 9'	II	Around the 9	Mercury's last appearance in the east ...., omitted	44.433	-0.675
-93 A	Rev.' 22	V	Around the 4	Mercury's first appearance in the east in the end of Cancer	109.632	-1.506
-93 A	Rev.' 19	V	Around the 22	Mercury's last appearance in the east in Leo	133.444	1.772
-90	'Obv. 48'	X	Around the 7	Mercury's last appearance in the west in Capricorn	287.46	1.652
-90	'Obv. 48'	X	Around the 22	Mercury's first appearance in the east in Capricorn	273.102	3.374
-90	Rev.' 19	XII	Around the 2	Mercury's last appearance in the east in Aquarius	309.096	-2.102
-87 A	'Rev.' 13'	VI	Around the 11	Mercury's last appearance in the east in the end of Leo	146.216	1.866
-87 C	'Rev. 40'-41'	XII_2	[16 or 17]	.... Mercury's] first appearance in the east in the end of Pisces;... (ideal) first appearance on the 15th in Pisces.	341.418	-2.314
-87 C	'Rev. 45'	XII_2	27	Mercury's last appearance in the east in Aries	353.698	-2.845
-86 A	'Rev.' 6'	V	Around the 4	Mercury's last appearance in the east in Leo	129.017	1.742
-86 B	Line 12'	VIII	1	Mercury's first appearance in the east in the beginning of Scorpius; ..., [(ideal) first appearance] on the 28th [of month VII ....]	208.081	2.474
-85 B	Line 8'	VII	Around the 7	Mercury's last appearance in the west ...., omitted.	208.039	-2.846
-85 C	Rev.' 3	X	[10]	Mercury's first appearance in the west in Aquarius;]..., (ideal) first appearance on the 9th in the beginning of Aquarius	295.671	-1.376
-85 C	Rev.' 16	XI	4	Mercury's last appearance in the west in Aquarius: from the 1st, when I watched I did not see it	310.524	3.651
-85 C	Rev.' 23-24	XI	Around the 19	Mercury's [first appearance] in the east [in Aquarius ....]	299.183	1.982
-85 C	'Rev.' 12'	XII	Around the 22	Mercury's last appearance in the east in Pisces	331.397	-2.412
-83	'Obv.' 10'	III	6	Mercury's first appearance in the east in Gemini	60.391	-1.738
-82 B	'Rev.' 11'	XII_2	Around the 10	Mercu[ry's last appearance in the west in Aries ....]	15.699	2.486

Diary No.	Line	Record			Tropical longitude	Latitude
-78	Line 2'	VI	1 to 10	[.... Mercury's] last appearance [in the west ....], omitted	191.232	-2.463
-77 A	'Obv. 5'	I	Around the 5?	Mercury's first appearance in the west in Taurus	27.296	1.085
-77 A	'Obv. 18'	II	Around the 13	Mercury's last appearance in the west in Gemini;	67.227	-0.92
-77 A	'Obv. 37'	III	18	, Mercury's first appearance in the east in Gemini, ... (ideal) first appearance on the 16th	66.179	-2.095
-77 A	Rev.' 6	IV	Around the 2	Mercury's last appearance in the east in the end of Gemini	87.135	0.663
-77 A	Rev.' 22	V	13	Mercury's first appearance in the west in Virgo; ... (ideal) first appearance on the 12th .... [....]	160.399	-0.596
-77 A	Rev.' 28	V	Around the 29	Mercury's last appearance in the west in the end of Virgo;	179.449	-2.72
-77 A	Rev.' 32	VI	2	last appearance of Mercury in the west in the end of Virgo…	181.937	-3.044
-77 B	'Obv.' 10'	VII	Around the 30	Mercury's last appearance in the east in Libra	204.448	0.797
-77 B	'Rev.' 12'	XI	Around the 28	Mercury's last appearance in the east in Aquarius	311.867	-2.146
-73	Line 10'	III	Around the 16	Mercury's last appearance in the west in the beginning of Leo	116.966	-3.606
-60	'Obv. 5'	VIII	7	Mercury's [last appearance] in the west in Scor[pius ....]	228.796	-1.615
-60	Rev.' 4	VIII	Around the 23	Mercury's first appearance in the east in Scorpius	213.048	2.669

Appendix K2: Mercury phenomena from the planetary texts (ADART Vol. V)

ADART Vol. V No.		Observation date									Tropical Longitude	Latitude
59	Obv. III 3'	A II year 15	V	24	[last]	appearance in the	east	in	end [of Leo]		138.385	1.842
59	Obv. III 4'	Arta II year 15	[VII]	25	last	appearance in the	west		omitted		226.643	-2.451
59	Obv. III 5'	Arta II year 15	[VIII]	[…]	first	appearance in the	[east]		[…]	(ideal) first on 12	215.799	2.086
59	Obv. III 7'	Arta II year 15	[IX?]	30	last	appearance in the	east	in	Sagittarius		259.694	-1.345
59	Obv. III 8'	Arta II year 16	XI		first	appearance in the	west	in	Aquarius	(ideal) first on 28 of X	308.164	-1.276
59	Obv. III 9'	Arta II year 16	XI	25	last	appearance in the	west	in	Pisces		334.433	3.703
59	Obv. III 9'-10'	Arta II year 16	XII	28	first	appearance in the	east	in	Pisces		330.311	-2.086
59	Obv. III 11'	Arta II year 16	I	13 or 14	last	appearance in the	east	in	end of Pisces		349.263	-2.638
59	Obv. III 12'-13'	Arta II year 16	II	18	first	appearance in the	west	in	beginning of Gemini	(ideal) first on 14	56.091	1.786

ADART Vol. V No.		Observation date									Tropical Longitude	Latitude
59	Obv. III 14'	Arta II year 16	IV	1	last	appearance in the	west	in	Cancer		101.335	-3.303
59	Obv. III 14'-15'	Arta II year 16	IV	27	first	appearance in the	east	in	beginning of Cancer	(ideal) first on 25	91.49	-1.866
59	Obv. III 15'-16'	Arta II year 16	V	16	last	appearance in the	[east]	in	beginning of Leo		119.26	1.687
59	Obv. III 16'	Arta II year 16	VI_2	5	first	appearance in the	west		omitted		197.019	-2.199
59	Obv. III 16'-17'	Arta II year 16	VI_2	15	last	appearance in the	west		omitted		208.139	-2.851
59	Obv. III 17'-18'	Arta II year 16	VII	13	first	appearance in the	east	in	Libra	(ideal) first on 8	196.523	2.306
59	Obv. IV 10'	Arta II year 19	[X]	[2]5	last	appearance in the	east	in	Capricorn		293.537	-1.907
59	Obv. IV 11'	Arta II year 19	XI	[…]	first	appearance in the	[west]		[…]	(ideal) first on 24	347.443	-0.196
59	Obv. IV 13'	Arta II year 20	II^2	25	last	appearance in the	east		omitted		55.695	0.055
59	Obv. IV 13'-14'	Arta II year 20	III	Around the 13	[first]	appearance in the	[west]		[…]		92.729	1.865
59	Obv. IV 14'	Arta II year 20	[IV]	[2]9	last	appearance in the	west	in	Leo		147.562	-3.874
59	Obv. IV 14'-15'	Arta II year 20	V	22	[first]	appearance in the	east	in	end [of Leo]	(ideal) first [on 1]9	133.011	-0.489
59	Obv. IV 16'-17'	Arta II year 20	VIII	10	first	appearance in the	west	in	Sagittarius		245.266	-2.233
59	Obv. IV 17'	Arta II year 20	VIII	22	last	appearance in the	west	in	Sagittarius		253.466	-0.289
59	Obv. IV 17'-18'	Arta II year 20	IX	10	first	appearance in the	east	in	Sagittarius	(ideal) first on 8	237.392	3.165
59	Obv. IV 19'	Arta II year 20	X	19	last	appearance in the	east	in	Capricorn		279.099	-1.64
59	Obv. IV 19'-20'	Arta II year 20	XI	21	first	appearance in the	west	in	Pisces	(ideal) first on 20	335.388	-0.362
59	Obv. IV 22'-23'	Arta II year 20	XII_2	26	first	appearance in the	east		omitted		3.115	-3.181
59	Obv. IV 24'	Arta II year 21	I	Around the 12	[last]	appearance in the	[east]		omitted		26.118	-1.704
59	Obv. IV 24'-25'	Arta II year 21	II	8	first	appearance in the	west	in	Gemini		77.234	1.856
59	Obv. IV 26'	Arta II year 21	III	22	last	appearance in the	west	in	Leo		130.32	-3.606
59	Obv. IV 27'	Arta II year 21	I[V]	[1]5	first	appearance in the	east	in	Leo	(ideal) first on 13	116.779	-1.927

ADART Vol. V No.		Observation date									Tropical Longitude	Latitude
59	Obv. IV 28'-29'	Arta II year 21	VII	3	first	appearance in the	west	in	Scorpius		227.741	-2.513
59	Obv. IV 29'-30'	Arta II year 21	VIII	3	first	appearance in the	east	in	Scorpius	(ideal) first on 29 of VII	221.859	2.968
59	Obv. IV 31'-32'	Arta II year 21	IX	Around the 12	last	appearance in the	east	in	Sagittarius		261.764	-1.175
59	Obv. IV 32'	Arta II year 21	X	15	first	appearance in the	west	in	Aquarius	(ideal) first on 13 or 14	319.421	-0.867
59	Obv. IV 33'	Arta II year 21	XI	Around the 10	last	appearance in the	west	in	Pisces		345.498	3.586
59	Obv. IV 33'-34'	Arta II year 21	XII	18	[first]	appearance in the	east		[…]	(ideal) first on 16 or 17	344.166	-2.737
59	Obv. V 4'	Arta II year 24	VI	16	first	appearance in the	east	in	Libra	(ideal) first on 14	174.897	0.885
59	Obv. V 5'	Arta II year 24	VIII	22	[last]	appearance in the	east	in	Sagittarius		213.769	0.233
59	Obv. V 6'	Arta II year 24	VIII	30	first	appearance in the	west	in	Capricorn		274.53	-1.889
59	Obv. V 7'	Arta II year 24	X	9	first	appearance in the	east	in	Capricorn		279.96	2.591
59	Obv. V 9'	Arta II year 24	XI	Around the 13	last	appearance in the	east	in	Aquarius		312.28	-2.177
59	Obv. V 14'	Arta II year 25	II	29	[first]	appearance in the	east		[…]	(ideal) first on 25	54.273	-2.346
59	Obv. V 20'	Arta II year 25	VI	13	[first]	appearance in the	east	in	Virgo		158.315	0.587
59	Obv. V 23'	Arta II year 25	VII	8	last	appearance in the	east	in	Libra		187.078	1.387
59	Obv. V 23'-24'	Arta II year 25	VIII	29	first	appearance in the	west	in	end of Sagittarius	(ideal) first on 24	265.526	-1.909
59	Obv. V 24'-25'	Arta II year 25	IX	16	last	appearance in the	west	in	Capricorn		278.129	1.709
59	Obv. V 25'-26'	Arta II year 25	X	1	first	appearance in the	east	in	end of Sagittarius	(ideal) first on 27 of IX	263.601	3.287
59	Obv. V 27'	Arta II year 25	XI	Around the 9	last	appearance in the	east	in	Aquarius		299.032	-1.957
59	Obv. V 28'	Arta II year 25	XII	12	first	appearance in the	west	in	Aries	(ideal) first on 11	1.158	0.503
59	Obv. V 30'-31'	Arta II year 26	I	15	last	appearance in the	west	in	Taurus		33.793	1.115
59	Obv. V 31'	Arta II year 26	II	16	first	appearance in the	east		omitted		29.624	-3.621
59	Obv. V 32'	Arta II year 26	III	3	last	appearance in the	east		omitted		51.642	-0.975
59	Obv. V. 32'-33'	Arta II year 26	IV	6	first	appearance in the	west	in	Leo	(ideal) first on 1	114.554	1.486

ADART Vol. V No.		Observation date									Tropical Longitude	Latitude
59	Rev. VI 3'	Arta II year 27	IV	7	last	appearance in the	west	in	Leo		140.249	-3.494
59	Rev. VI 4'	Arta II year 27	[V]	[…]	[first]	appearance in the	[east]		[…]	(ideal) first on 1	126.342	-1.439
59	Rev. VI 4'-5'	Arta II year 27	[V]	25	[last]	appearance in the	east		[…]		154.463	1.837
59	Rev. VI 6'	Arta II year 27	[VIII]	19?	first	appearance in the	east	in	Scorpius		231.124	3.157
59	Rev. VI 7'	Arta II year 27	IX?	29?	last	appearance in the	east	in	Capricorn		273.316	-1.53
59	Rev. VI 7'-8'	Arta II year 27	XI	3	[first]	appearance in the	west		[…]		330.837	-0.387
59	Rev. VI 8'	Arta II year 27	XII	29	first	appearance in the	east		omitted		349.632	-2.69
59	Rev. VI 9'	Arta II year 28	II	19	first	appearance in the	west		[…]		72.901	1.878
59	Rev. VI 11'	Arta II year 28	IV	3	last	appearance in the	west	in	Leo		122.868	-3.586
59	Rev. VI 12'	Arta II year 28	IV	29	first	appearance in the	east		[…]	(ideal) first on 24	110.656	-0.995
59	Rev. VI 13'	Arta II year 28	V	20	[last]	appearance in the	east		[…]		141.252	1.84
59	Rev. VI 13'	Arta II year 28	VI?	28	[last]	appearance in the	[west]		[…]		202.836	-1.638
59	Rev. VI 14'	Arta II year 28	[VI]I	15	first	appearance in the	west	in	Scorpius		223.915	-2.602
59	Rev. VI 17'	Arta II year 28	XI	23	[last]	appearance in the	west		[…]		336.662	3.693
59	Rev. VI 19'	Arta II year 29	I	10	last	appearance in the	east	in	Aries		352.165	-2.642
59	Rev. VI 19'	Arta II year 29	II	14	[first]	appearance in the	[west]		[…]	(ideal) first on 10	57.106	1.746
59	Rev. VI 20'	Arta II year 29	III	27	[last]	appearance in the	west		[…]		104.509	-3.178
59	Rev. VI 21'	Arta II year 29	[IV]	[…]	first	appearance in the	east	in	Cancer	(ideal) first on 21	93.025	-2.543
59	Rev. VI 22'	Arta II year 29	VII	7	first	appearance in the	west		omitted		206.808	-2.678
59	Rev. VI 22'	Arta II year 29	VII	21	last	appearance in the	west		omitted		214.946	-2.17
59	Rev. VI 22'-23'	Arta II year 29	[VIII]	7	first	appearance in the	east	in	Libra	(ideal) first on 6	199.772	2.131
59	Rev. VI 25'	Arta II year 29	IX	7	last	appearance in the	east	in	Sagittarius		228.456	0.289
59	Rev. VI 27'	Arta II year 29	XI	14	last	appearance in the	west	in	Aquarius		320.814	3.37
59	Rev. VI 27'-28'	Arta II year 29	XII	8	first	appearance in the	east	in	Aquarius	(ideal) first on 4	308.574	0.297
63	Rev. 12	Arta II year 41	I	6	first	appearance in the	east		omitted		2.689	-3.035
63	Rev. 12	Arta II year 41	I	20	last	appearance in the	east		omitted		24.458	-1.591
63	Rev. 13	Arta II year 41	III	29	last	appearance in the	west	in	Leo		125.715	-3.645

ADART Vol. V No.		Observation date									Tropical Longitude	Latitude
63	Rev. 13-14	Arta II year 41	IV	27	first	appearance in the	east	in	Leo	(ideal) first on 21	112.572	-2.327
63	Rev. 14-15	Arta II year 41	V	18	last	appearance in the	east	in	Virgo		144.105	1.833
63	Rev. 15	Arta II year 41	VII	8	first	appearance in the	west		[…]		221.89	-2.513
63	Rev. 15	Arta II year 41	VII	21	last	appearance in the	west		[…]		233.332	-1.872
63	Rev. 15-16	Arta II year 41	VIII	10	first	appearance in the	east	in	Scorpius	(ideal) first on 8	218.048	2.812
63	Rev. 17	Arta II year 41	IX	23	last	appearance in the	[east]	in	Sagittarius		264.997	-1.467
63	Rev. 17	Arta II year 41	X	21	first	appearance in the	west	in	Aquarius		314.09	-1.089
63	Rev. 18	Arta II year 41	[XI]	28	last	appearance in the	west	in	Pisces		332.632	2.347
63	Rev. 18	Arta II year 41	XII	17	first	appearance in the	east	in	Pisces		332.85	-1.813
65	Obv.' I' 6	Arta II year 43	X	13	first	appearance in the	west	in	end of Capricorn		286.487	-1.639
65	Obv.' I' 7	Arta II year 43	[XI]	5	last	appearance in the	west	in	Aquarius		306.246	3.135
65	Obv.' I' 7	Arta II year 43	[XI]	20	first	appearance in the	east	in	[Aquarius]	(ideal) first on 16	293.295	2.705
65	Obv.' I' 8	Arta II year 43	XII	27	last	appearance in the	east	in	Pisces		327.235	-2.375
65	Obv.' I' 9	Arta II year 44	I	2	[first]	appearance in the	west	in	Taurus	(ideal) first on 25 of XII_2	34.071	1.644
65	Obv.' I' 12	Arta II year 44	II	20	last	appearance in the	west	in	[Gemini]		63.063	-4.108
65	Obv.' I' 13	Arta II year 44	III	10	first	appearance in the	east	in	Gemini	(ideal) first on 6	64.776	-2.406
65	Obv.' I' 14	Arta II year 44	III	27	last	appearance in the	east	in	Cancer		91.779	1.097
65	Obv.' I' 14-15	Arta II year 44	V	2	first	appearance in the	west	in	Virgo	(ideal) first on 27 of IV	153.208	-0.018
65	Obv.' I' 15	Arta II year 44	V	27	last	appearance in the	west	in	Virgo		182.981	-3.106
65	Obv.' I' 15-16	Arta II year 44	[VI]	24?	first	appearance in the	[east]	in	Virgo	(ideal) first on 21	170.23	1.014
65	Obv.' I' 17-18	Arta II year 44	VII	26	[last]	appearance in the	east		[…]		207.627	0.506
65	Obv.' I' 18	Arta II year 44	[IX]	6	first	appearance in the	west	in	Capricorn		269.554	-1.994
65	Obv.' I' 19	Arta II year 44	X	12	[first]	appearance in the	east		[…]		277.09	3.452
65	Obv.' I' 20	Arta II year 44	XI	25	[last]	appearance in the	east		[…]		317.14	-2.238
65	Obv.' II' 3'	Arta III year 3	III	5	last	appearance in the	west	in	Cancer		99.228	-3.399
65	Obv.' II' 3'	Arta III year 3	III	28	[first]	appearance in the	[east]		[…]		88.743	-2.602
65	Obv.' II' 4'	Arta III year 3	IV	19	last	appearance in the	east	in	Leo		116.939	1.633

ADART Vol. V No.		Observation date								Tropical Longitude	Latitude
65	Obv.' II' 5'	Arta III year 3	[VI]	23	last	appearance in the	west		omitted	200.032	-2.504
65	Obv.' II' 6'	Arta III year 3	VII	21	[last]	appearance in the	east	in	beginning of Capricorn	198.98	1.015
65	Obv.' II' 7'	Arta III year 3	X	21	last	appearance in the	west	in	end of Aquarius	315.576	3.518
65	Obv.' II' 8'	Arta III year 3	XII	10	[last]	appearance in the	east	in	Pisces	331.54	-2.471
65	Obv.' II' 9'	Arta III year 4	I	Around the 3	first	appearance in the	west	in	Taurus	11.863	-0.559
65	Obv.' II' 11'	Arta III year 4	II	Around the 27	last	appearance in the	west	in	Cancer	79.87	-2.512
65	Obv.' II' 12'	Arta III year 4	III	Around the 24	first	appearance in the	east	in	Gemini	72.899	-2.59
65	Obv.' II' 13'	Arta III year 4	IV	14	[last]	appearance in the	east	in	Cancer	101.223	1.335
65	Obv.' II' 14'	Arta III year 4	V	Around the 28	first	appearance in the	west	in	Libra	175.689	-1.506
65	Obv.' II' 15'	Arta III year 4	VII	Around the 9	first	appearance in the	east	in	Libra	179.767	1.258
65	Obv.' II' 16'	Arta III year 4	VIII	12	last	appearance in the	east	in	Scorpius	215.937	0.31
65	Obv.' II' 17'	Arta III year 4	X	14	last	appearance in the	west	in	Aquarius	299.677	2.721
65	Obv.' II' 26'	Arta III year 5	IX	18	[first]	appearance in the	west	in	end of Sagittarius	265.027	-2.039
65	Obv.' II' 26'	Arta III year 5	X	8	last	appearance in the	west	in	Capricorn	283.65	1.773
65	Obv.' II' 27'	Arta III year 5	XII	5	last	appearance in the	east	in	Aquarius	309.429	-2.161
65	Obv.' II' 27'	Arta III year 5	XII_2	4	[first]	appearance in the	west		[…]	5.283	0.559
65	Obv.' II' 28'	Arta III year 6	I	10	last	appearance in the	west	in	Taurus	39.99	0.504
65	Obv.' II' 28'	Arta III year 6	II	14	first	appearance in the	east		omitted	40.145	-2.995
65	Obv.' II' 28'-29'	Arta III year 6	II	25	last	appearance in the	east		omitted	55.87	-0.925
65	Obv.' II' 29'	Arta III year 6	III	Around the 23	first	appearance in the	west	in	Leo	111.311	1.693
65	Obv.' II' 29'	Arta III year 6	V	4	[last]	appearance in the	west	in	Virgo	161.464	-3.294
65	Obv.' II' 30'	Arta III year 6	VI	1	first	appearance in the	east	in	Virgo	147.535	0.408
65	Obv.' II' 31'	Arta III year 6	VI	27	last	appearance in the	east	in	beginning of Libra	181.381	1.314
65	Obv.' II' 31'	Arta III year 6	VIII	Around the 12	[first]	appearance in the	west	in	[Capricorn]	250.053	-2.229
65	Obv.' II' 32'	Arta III year 6	IX	2	last	appearance in the	west	in	Capricorn	267.716	0.744
65	Obv.' II' 33'	Arta III year 6	XII	Around the 1	[first]	appearance in the	west	in	Pisces	353.086	0.41
65	Obv.' II' 34'	Arta III year 7	I	1	last	appearance in the	west	in	Taurus	20.202	1.99
65	Obv.' II' 34'	Arta III year 7	II	6	first	appearance in the	east		omitted	20.088	-3.331
65	Obv.' II' 34'	Arta III year 7	II	20+x	[last]	appearance in the	[east]		[omitted]	39.809	-1.421

ADART Vol. V No.		Observation date									Tropical Longitude	Latitude
65	Obv.' II' 35'	Arta III year 7	III	15	first	appearance in the	west	in	Cancer		90.426	1.865
65	Obv.' II' 36'	Arta III year 7	IV	28	[last]	appearance in the	west	in	be[ginning of …]		145.539	-3.425
65	Obv.' II' 37'	Arta III year 7	V	Around the 21	first	appearance in the	east	in	Leo		132.178	-1.693
65	Obv.' II' 37'	Arta III year 7	VI	16	[last]	appearance in the	east		[…]		157.789	1.855
65	Obv.' II' 38'	Arta III year 7	[VIII]	26	last	appearance in the	west	in	Sagittarius		251.809	-0.228
65	Obv.' II' 39'	Arta III year 7	X	24	last	appearance in the	east	in	Capricorn		280.292	-1.716
65	Obv.' II' 41'	Arta III year 8	II	1	first	appearance in the	east		omitted		3.223	-3.122
65	Obv.' II' 41'	Arta III year 8	II	17	last	appearance in the	east		omitted		27.453	-1.495
65	Obv.' II' 1"	Arta III year 9	II	5	[first]	appearance in the	west	in	Gemini		59.077	1.667
65	Obv.' II' 3"	Arta III year 9	V	4	last	appearance in the	east	in	behind alpha Leonis		124.306	1.71
65	Obv.' II' 4"	Arta III year 9	VII	12?	last	appearance in the	west		omitted		220.152	-2.361
65	Obv.' II' 4"	Arta III year 9	VII	Around the 27	first	appearance in the	east	in	Libra		206.911	1.82
65	Obv.' II' 6"	Arta III year 9	IX	10	[last]	appearance in the	[east]		[…]		247.345	-0.877
65	Obv.' II' 7"	Arta III year 9	XI	7	[last]	appearance in the	west	in	Pisces		326.222	3.496
65	Obv.' II' 8"	Arta III year 9	XI		first	appearance in the	[east]	in	Aquarius	(ideal) first on 25?	313.693	1.432
65	Rev.' I 1	Arta III year 10	IV	9	first	appearance in the	east	in	beginning of Cancer		82.13	-2.533
65	Rev.' I 2	Arta III year 10	IV?	28	last	appearance in the	east	in	Leo		108.649	1.44
65	Rev.' I 3	Arta III year 10	VII	1	last	appearance in the	west		omitted		202.35	-3.028
65	Rev.' I 3	Arta III year 10	VII	Around the 23	first	appearance in the	east	in	Libra		189.431	1.504
65	Rev.' I 4	Arta III year 10	[VIII]	30	last	appearance in the	east	in	Scorpius		227.277	-0.12
65	Rev.' I 5-6	Arta III year 10	X	Around the 11	first	appearance in the	west	in	Capricorn		292.782	-1.33
65	Rev.' I 6	Arta III year 10	XI	1	last	appearance in the	west	in	Aquarius		308.857	3.241
65	Rev.' I 6	Arta III year 10	XI	Around the 15	first	appearance in the	east	in	Pisces		296.498	2.816
65	Rev.' I 7	Arta III year 10	XII	20	last	appearance in the	east	in	Pisces		323.744	-2.358
65	Rev.' I 7	Arta III year 10	XII_2	27	first	appearance in the	west	in	Taurus		33.153	1.45
65	Rev.' I 9	Arta III year 11	III	Around the 5	first	appearance in the	east	in	Gemini		65.922	-2.74
65	Rev.' I 10	Arta III year 11	III?	23	[last]	appearance in the	[east]		[…]		92.801	1.057
65	Rev.' I 10-11	Arta III year 11	V	Around the 20	[last]	appearance in the	west		[…]		182.345	-2.749
65	Rev.' I 6	Arta III year 12	[VII?]	13?	last	appearance in the	east	in	Libra		188.261	1.26

ADART Vol. V No.		Observation date									Tropical Longitude	Latitude
65	Rev.' I 9'	Arta III year 12	XII	15	[first]	appearance in the	west	in	Aries		0.728	0.547
65	Rev.' I 11'	Arta III year 13	II	19	first	appearance in the	east		omitted		27.538	-3.628
65	Rev.' I 13'	Arta III year 13	VI?	9	first	appearance in the	east	in	Virgo		141.178	-0.833
65	Rev.' I 14'	Arta III year 13	VIII	28	first	appearance in the	west	in	Sagittarius		250.994	-2.164
65	Rev.' I 15'	Arta III year 13	IX?	Around the 22	[first]	appearance in the	east	in	Sagittarius		250.397	3.165
65	Rev.' I 16'	Arta III year 13	XII	10	[first]	appearance in the	west	in	Pisces		344.535	0.008
65	Rev.' I 18'	Arta III year 13	XII_2	12	[last]	appearance in the	west	in	Aries		10.998	2.061
65	Rev.' I 21'	Arta III year 14	IV	12	[last]	appearance in the	west	in	[Leo]		138.713	-3.737
65	Rev.' I 21'-22'	Arta III year 14	V	29	last	appearance in the	east	in	Virgo		154.057	1.821
65	Rev.' I 24'	Arta III year 14	XI	Around the 4	[first]	appearance in the	west		[…]		326.515	-0.697
65	Rev.' I 26'	Arta III year 15	I	2	first	appearance in the	east		omitted		347.55	-2.577
65	Rev.' I 29'	Arta III year 15	IV	15		appearance in the	west		[…]		116.352	-4.622
65	Rev.' I 32'	Arta III year 15	V?	22	last	appearance in the	east	in	Leo		133.496	1.817
65	Rev.' I 33'	Arta III year 15	VIII	19	first	appearance in the	east	in	Scorpius		213.233	2.832
65	Rev.' I 35'	Arta III year 15	IX?	27	last	appearance in the	east	in	Sagittarius		257.209	-1.164
65	Rev.' I 35'-36'	Arta III year 15	[XI]	25	[last]	appearance in the	west	in	Pisces		335.628	3.689
65	Rev.' I 37'	Arta III year 16	I	11	[last]	appearance in the	east	in	Aries		346.976	-2.705
67	II' 2'	SE 6	V	24	[first]	appearance in the	east		[…]		132.539	-0.456
67	II' 2'-3'	6	VIII	25	last	appearance in the	west	in	Sagittarius		252.56	0.039
67	II' 4'-5'	6	IX	11?	[first]	appearance in the	east		[…]	(ideal) first on 8 or 9	237.275	3.231
67	II' 6'	6	XI	25	[first]	appearance in the	[west]		[…]	(ideal) first on 22	339.469	0.03
67	II' 8'	6	XII	23	[last]	appearance in the	west	in	Aries		2.019	2.992
67	II' 13'	7	II?	1	first	appearance in the	east		omitted		5.209	-3.109
67	II' 13'	7	II	17	last	appearance in the	east		omitted		29.98	-1.349
67	II' 13'	7	III	12	first	appearance in the	west	in	Cancer	(ideal) first on 10	79.487	1.902
67	II' 16'	7	V	20	first	appearance in the	east	in	Leo		116.615	-0.961
67	II' 17'	7	VIII	14	[last]	appearance in the	west	in	Scorpius		236.132	-2.057
67	II' 18'	7	X?	16	last	appearance in the	[east]	in	Scorpius		265.158	-1.362
68	B 3'	7	IX	4	[first]	appearance in the	[east]		[…]	(ideal) first on 3	221.654	2.894

ADART Vol. V No.		Observation date									Tropical Longitude	Latitude
68	B 4'	7	X	17	last	appearance in the	east	in	end of Sagittarius		263.586	-1.276
68	B 4'-5'	7	XI	[…]	first	appearance in the	west	in	Aquarius	(ideal) first on 16	315.809	-1.146
68	B 5'	7	XII	14	[last]	appearance in the	west	in	Pisces		344.166	3.618
68	B 6'	7	XII_2	18	first	appearance in the	east	in	Pisces	(ideal) first on 14	340.893	-2.515
68	B 6'	7	XII_2	29	[last]	appearance in the	east		[…]		354.222	-2.79
68	B 7'	8	II	6	first	appearance in the	west	in	Gemini	(ideal) first on 4	63.776	1.822
68	B 8'	8	III	20	last	appearance in the	west	in	Cancer		111.433	-3.54
68	B 8'	8	IV	15	first	appearance in the	east	in	Cancer		100.243	-1.696
68	B 9'	8	V	3 or 4	last	appearance in the	east	in	Leo		123.085	1.643
68	B 9'-10'	8	VI	26	first	appearance in the	[west]		omitted		208.189	-2.44
68	B 12'	8	X	15	first	appearance in the	west	in	beginning of Aquarius	(ideal) first on 10+x	309.237	-0.871
68	B 13'	8	XI	7	last	appearance in the	west	in	beginning of Pisces		326.931	3.597
68	B 13'	8	XI	27	first	appearance in the	east	in	Aquarius		314.702	0.72
68	B 14'	8	XII	Around the 25	last	appearance in the	east	in	end of Pisces		341.423	-2.585
68	B 15'	9	II	2	first	appearance in the	west	in	beginning of Gemini	(ideal) first on 29 of I	49.866	1.725
68	B 17'	9	IV	10	first	appearance in the	east	in	Cancer		83.636	-2.312
68	B 18'	9	IV	28	last	appearance in the	east	in	Cancer		109.289	1.429
68	B 18'	9	VI	20	[first]	appearance in the	west		[omitted]		192.474	-2.295
68	B 19'	9	[VII]	25	first	appearance in the	east	in	Libra		189.581	1.906
68	B 21'	9	$VIII^?$	30	[last]	appearance in the	east	in	end [of Scorpius]		229.497	-0.223
68	B 22'	9	XI	1	[last]	appearance in the	west		[…]		309.396	3.399
70	Rev. II 23'	46	I	22	first	appearance in the	east		omitted		16.502	-3.016
70	Rev. II 24'	46	III	1	first	appearance in the	west	in	Cancer		88.347	1.906
70	Rev. II 25'	46	IV	13	last	appearance in the	west	in	Leo		137.969	-3.489
70	Rev. II 26'	46	V	[…]	first	appearance in the	east	in	Leo	(ideal) first on 4	124.907	-2.269
70	Rev. III 2'	48	[$IV^?$]	18	last	appearance in the	east	in	Leo		119.508	1.663
70	Rev. III 2'	48	VI	$9^?$	first	appearance in the	west		omitted		200.381	-2.397
70	Rev. III 5'-6'	48	X	19	last	appearance in the	west	in	Aquarius		318.482	3.299
70	Rev. III 6'	48	XI	10	first	appearance in the	east	in	Aquarius	(ideal) first on 7	305.214	1.337

ADART Vol. V No.		Observation date									Tropical Longitude	Latitude
70	Rev. III 7'	48	XII	10	last	appearance in the	east	in	Pisces		334.514	-2.487
70	Rev. III 8'	49	I	12?	first	appearance in the	[west]	in	Taurus		36.82	1.262
70	Rev. III 22'	50	I	7	[first]	appearance in the	west	in	Taurus		20.652	0.83
71	'Obv. I 2'-3'	14	II	22?	[first]	appearance in the	west	in	[Gemini]		73.156	1.889
71	'Obv. I 6'	14	IV	4	last	appearance in the	west	in	Leo		122.186	-3.467
71	'Obv. I 9'-10'	14	VIII	13	[first]	appearance in the	east		[…]		216.297	2.445
71	'Obv. II 1'	16	VI	9	[last]	appearance in the	[west]	in	Libra		195.486	-3.035
71	'Obv. II 4'	16	[X]	25	[first]	appearance in the	east	in	Capricorn		290.083	2.947
71	'Obv. II 6'	17	I	6	[first]	appearance in the	west	in	[Taurus]		25.197	1.127
73	'Obv. I 8'	54	[IX]	9	[last]	appearance in the	east		…		250.259	-0.961
73	'Obv. I 16'	55	I	Around the 29	first	appearance in the	west	in	Gemini		48.469	1.6
73	'Obv. I 20'	55	III	14 or around the 10	last	appearance in the	west	in	Cancer		92.942	-3.459
73	'Obv. I 22'	55	IV	7	[first]	appearance in the	east		[…]		84.057	-2.609
73	Obv. I 23'	55	[IV]	28	last	appearance in the	east	in	Leo		113.832	1.592
73	'Obv. I 27'	55	VII	[…]	first	appearance in the	[east]	in	Libra	(ideal) first on 22	191.795	1.452
73	Rev. III 6	55	[VIII]	29	last	appearance in the	east	in	Scorpius		228.64	-0.101
73	Rev. III 7	55	X	12	first	appearance in the	west	in	end of Capricorn	(ideal) first on 9	299.091	-0.916
73	Rev. III 9	55	XI	1	last	appearance in the	west	in	Aquarius		310.603	3.371
73	Rev. III 10	55	XI	25?	first	appearance in the	east		[…]		299.547	0.419
73	Rev. III 11	55	XII	19	last	appearance in the	east		[…]		326.705	-2.39
73	Rev. III 17-18	56	III	4	last	appearance in the	west	in	Gemini		73.918	-1.985
73	Rev. III 18-19	56	IV	6	first	appearance in the	[east]	in	[Gemini]		70.368	-2.121
73	Rev. III 19	56	IV	23	[last]	appearance in the	east		[…]		96.065	1.161
73	Rev. IV 6-7	56	XI	Around the 16?	last	appearance in the	east	in	Aquarius		314.737	-2.207
73	Rev. IV 7-9	56	XII	22	first	appearance in the	west	in	beginning of Taurus	(ideal) first on 20	24.174	1.495
76	Obv. 5'	83	VIII	Around the 4	last	appearance in the	east	in	Libra		195.001	1.157
76	Obv. 6'	83	X	10	last	appearance in the	west	in	Capricorn		284.084	1.775

ADART Vol. V No.		Observation date									Tropical Longitude	Latitude
76	Obv. 8'	83	[XII]	Around the 7	last	appearance in the	east	in	Aquarius		310.328	-2.158
76	Obv. 8'	83	XII_2	6	first	appearance in the	west	in	Aries		6.122	0.556
76	Obv. 10'	84	I	10 or 11	last	appearance in the	west	in	Taurus		40.354	0.748
76	Obv. 10'-11'	84	II	20	first	appearance in the	east	in	Taurus	(ideal) first on 18	45.707	-2.309
76	Obv. 11'	84	II	Around the 30	last	appearance in the	east	in	Gemini		62.214	-0.318
76	Obv. 11'	84	IV	1	[first]	appearance in the	west	in	beginning of Leo		121.071	1.357
76	Obv. 12'	84	V	1	last	appearance in the	west	in	end? of Leo		159.727	-2.782
76	Obv. 12'	84	VI	3	first	appearance in the	[east]	in	Virgo		148.115	0.401
76	Obv. 13'	84	VIII	19	first	appearance in the	west	in	Sagittarius		258.055	-2.047
76	Obv. 15'	84	XII	4	first	appearance in the	west	in	beginning of Aries	(ideal) first on 2	355.857	0.603
76	Obv. 17'	85	I	3	last	appearance in the	west	in	beginning of Taurus		20.287	1.985
76	Obv. 17'	85	II	13	first	appearance in the	east		omitted		26.644	-2.833
76	Obv. 18'	85	III	19	first	appearance in the	west	in	Cancer		95.21	1.872
76	Obv. 19'	85	V	3	last	appearance in the	west	in	end of Leo		146.363	-3.752
76	Obv. 19'-20'	85	V	27	first	appearance in the	east	in	Leo	(ideal) first on 24	132.049	-0.523
76	Obv. 21'	85	VIII	[…]	first	appearance in the	west	in	Sagittarius	(ideal) first on 14	244.107	-2.305
76	Obv. 22'	85	VIII	Around the 29	last	appearance in the	[west]	in	Sagittarius		251.302	0.391
76	Obv. 22'	85	IX	12	first	appearance in the	east	in	beginning of Sagittarius?		237.597	3.208
76	Obv. 23'	85	XI	29	[first]	appearance in the	west	in	Pisces	(ideal) first on 27	341.516	0.248
76	Obv. 24'	85	[XII?]	6?	last	appearance in the	west	in	Aries		351.654	1.503
81	I' 1'	138	II?	4?	last?	appearance in the	east?		omitted?		40.322	-1.068
81	I' 2'	138	III	[…]	first	appearance in the	west		[…]	(ideal) first on 28 of II	89.624	1.899
81	I' 6'	138	IV	Around the 10	last	appearance in the	west	in	Leo		140.039	-3.438
81	I' 7'-8'	138	[V]	[…]	[first]	appearance in the	east	in	Leo	(ideal) first on 5	126.256	-1.398
81	I' 9'-10'	138	VIII	1	first	appearance in the	west	in	Sagittarius		245.382	-1.866
81	I' 10'	138	VIII	11	[last]	appearance in the	west		[…]		243.979	0.661
81	II' 4'	139	[IV?]	Around the 6	last	appearance in the	west	in	Leo		122.563	-3.51
81	II' 4'-5'	139	V	6?	[first]	appearance in the	east		[…]	(ideal) first on 1	112.417	-0.404

ADART Vol. V No.		Observation date								Tropical Longitude	Latitude
81	II' 5'	139	V	25	last	appearance in the	east	[…]		142.438	1.829
81	II' 6'	139	VII	17	first	appearance in the	west	omitted		222.503	-2.62
81	II' 7'	139	VIII	17	first	appearance in the	east	in Scorpius	(ideal) first on 13	215.025	2.769
81	II' 10'	139	IX?	[…]	last	appearance in the	east	in Sagittarius	from the 26 did not see it	257.284	-1.069
81	II' 14'	140	[I]	14?	last	appearance in the	east	in Aries		351.51	-2.653
81	II' 14'	140	II?	17	[first]	appearance in the	west	[…]		56.187	1.667
81	II' 18'-19'	140	IV?	27	[first]	appearance in the	east	in Cancer	(ideal) first on 25	93.961	-1.938
81	II' 20'	140	[V]	Around the 17	last	appearance in the	east	in beginning of Leo		121.432	1.672
81	II' 21'	140	VII	9	first	appearance in the	west	omitted		204.293	-2.534
81	II' 21'	140	VII	24?	last	appearance in the	west	omitted		215.191	-2.497
81	II' 24'-25'	140	IX	Around the 21	last	appearance in the	east	in Sagittarius		243.342	-0.753
81	II' 26'	140	X?		[first]	appearance in the	[west]	[…]	(ideal) first on 25	300.144	-1.343
81	II' 26'	140	[XI]	Around the 18	[last]	appearance in the	west	in end of Aquarius		320.319	3.415
81	II' 27'	140	XII?	Around the 7	first	appearance in the	east	in Aquarius		307.352	1.389
81	II' 28'	140	XII_2	10	last	appearance in the	east	[…]	from the 5 did not see it	339.096	-2.483
81	II' 29'	141	I	15?	first	appearance in the	west	in Taurus	(ideal) first on 13	46.218	1.747
81	III' 13'-14'	142	II	13	last	appearance in the	west	in Gemini		65.111	-0.431
81	III' 16'	142	V	[…]	first	appearance in the	[west]	[…]	(ideal) first on 10	151.73	0.039
81	III' 17'	142	VII	3	first	appearance in the	east	[…]	(ideal) first on 30 of VI	167.542	1.092
84	Line 4'	258?	[IX]	9	last	appearance in the	east	in Sagittarius		243.801	-0.458
84	Line 4'-5'	258?	X	15	first	appearance in the	west	in beginning of Aquarius	(ideal) first on 13	303.758	-1.431
84	Line 5'	258?	XI	6	[last]	appearance in the	west	in beginning? of Aquarius		328.81	2.972
84	Line 6'	258?	XI	x+18	first	appearance in the	east	in beginning of Pisces	(ideal) first on 15	315.324	1.161
84	Line 7'	258?	XII	Around the 25	last	appearance in the	east	in Pisces		337.114	-2.549
84	Line 8'	259?	II	2	first	appearance in the	west	in Gemini	(ideal) first on 1	47.521	1.497

Appendix K3: Mercury phenomena from the Goal-Year Texts (ADART Vol. VI)

ADART Vol. VI No.		Observation date (Seleucid Era)									Tropical Longitude	Latitude
1	A 3'	[30]	XII	29	[first]	appearance in the	[west]		[…]		18.07	1.3
5	Rev.' 9	35	I	Around the 22	[first]	appearance in the	west	in	beginning of Gemini		51.893	1.634
5	Rev.' 11	35	III	3	last	appearance in the	west	in	Cancer		98.915	-2.532
5	Rev.' 12	35	IV	21	[last]	appearance in the	east	in	Cancer		115.257	1.563
5	Rev.' 12	35	[VI]	12	first	appearance in the	west		omitted		197.744	-2.366
5	Rev.' 12-13	35	VII	Around the 17?	[first]	appearance in the	[east]		[…]		194.887	2.011
5	Rev.' 15	35	<X>	23	last	appearance in the	west	in	Aquarius		315.307	3.393
5	Rev.' 15	35	XI	11	first	appearance in the	east	in	Aquarius		302.334	1.706
7	Obv. 14	45	I	21	last	appearance in the	west		[…]	from the 17th I did not see it	30.653	1.281
7	Obv. 15	45	III	3	first	appearance in the	east		omitted		39.691	-2.224
7	Obv. 15	45	III	13	last	appearance in the	east		omitted		56.995	-0.31
7	Obv. 15	45	IV	9	first	appearance in the	west	in	Cancer	(ideal) first on 7	107.332	1.725
7	Obv. 15	45	V	20	last	appearance in the	west	in	beginning of Virgo		155.085	-3.746
7	Obv. 16	45	VI	14	first	appearance in the	east	in	end of Leo	(ideal) first on 11	140.303	-0.171
7	Obv. 16	45	VII	6	last	appearance in the	east	in	Virgo		167.425	1.767
7	Obv. 16	45	VIII	29	first	appearance in the	west	in	Sagittarius		249.738	-2.222
7	Obv. 16	45	IX	14	last	appearance in the	west	in	Sagittarius		260.436	0.341
7	Obv. 17	45	IX	Around the 26	first	appearance in the	east	in	Sagittarius		247.321	3.334
7	Obv. 17	45	XI	10	last	appearance in the	east	in	Capricorn		285.864	-1.75
7	Obv. 18	45	XII_2	Around the 10	last	appearance in the	west	in	Aries		11.898	2.897
9	'Obv.' 13'	49	II	27	last	appearance in the	west	in	Cancer		81.604	-2.964
9	'Obv.' 13'	49	III	Around the 20	first	appearance in the	east	in	end of Gemini		73.633	-3.125
9	'Obv.' 14'-15'	49	V	30	[first]	appearance in the	west		[…]		182.279	-1.967
9	'Obv.' 15'	49	VI	10	last	appearance in the	west	in	Libra		192.904	-2.961
9	'Obv.' 15'	49	VII	Around the 7	first	appearance in the	east	in	Libra		182.066	1.203
9	'Obv.' 16	49	VIII	11	last	appearance in the	east	in	Scorpius		218.328	0.254
9	'Obv.' 16	49	IX	22	first	appearance in the	west	in	Capricorn		283.275	-1.699
9	'Obv. 17'	49	XI	2	first	appearance in the	east	in	Capricorn		287.578	2.238
9	'Obv.' 18	49	XII	10	last	appearance in the	east		[…]		327.438	-2.314

ADART Vol. VI No.		Observation date (Seleucid Era)									Tropical Longitude	Latitude
10	Obv.' 22	50	I	7	first	appearance in the	west	in	beginning of Taurus		20.652	0.83
10	Obv.' 24-25	50	II	13	last	appearance in the	west	in	beginning of Gemini		62.857	0.041
10	Obv.' 25	50	II	17	last	appearance in the	west		[…]	from the 13th I did not see it	62.474	-1.026
10	Obv.' 26	50	IV	Around the 7	last	appearance in the	east		[…]		88.622	1.039
13	Line 2'	[51]	XII	1	[first]	appearance in the	[west]		[…]		358.267	0.752
12	'Obv. 2'	[51]	XII	29	[last]	appearance in the	west		[…]		22.615	2.017
15	Obv. 17	60	I	2	[first]	appearance in the	east		[…]		350.147	-2.68
15	Obv. 19	60	IV	4	[last]	appearance in the	west	in	[Leo]		123.268	-3.44
15	Obv. 20	60	VII	11	first	appearance in the	west		omitted		217.54	-2.439
15	Obv. 20	60	VII	26	[last?]	appearance in the	[west?]		[omitted?]		231.326	-2.019
15	Obv. 21	60	IX	27	last	appearance in the	east	in	Sagittarius		263.294	-1.411
16	'Obv.' 20'	61	I	9	[last]	appearance in the	east		[…]		348.453	-2.726
16	'Obv.' 20'	61	II	16	first	appearance in the	west	in	Gemini		57.968	1.748
16	'Obv.' 21'	61	III	30	[last]	appearance in the	[west]	in	Cancer		104.579	-3.439
16	'Obv.' 21'	61	IV	24	[first]	appearance in the	[east]		[…]		93.859	-2.26
16	'Obv.' 22'	61	VII	5	[first]	appearance in the	[west]		[omitted?]		201.785	-2.342
20	Obv. 23	72	I	2	last	appearance in the	west	in	Aries		18.216	2.784
20	Obv. 23	72	II	14	first	appearance in the	east		omitted		21.158	-3.077
20	Obv. 23	72	II	27	last	appearance in the	east		omitted		41.267	-1.162
20	Obv. 24	72	III	28	first	appearance in the	west	in	Cancer	(ideal) first on 25	101.552	1.758
20	Obv. 25	72	V	3	last	appearance in the	west	in	Leo		142.682	-3.09
20	Obv. 25	72	VI	1	first	appearance in the	east	in	Leo	(ideal) first on 29 of V	129.462	-0.616
20	Obv. 25-26	72	VI	24	last	appearance in the	east	in	Virgo		159.948	1.761
20	Obv. 26	72	VIII	20	first	appearance in the	west	in	Sagittarius		243.699	-2.262
20	Obv. 26	72	VIII	29	last	appearance in the	west	in	Sagittarius		249.959	-0.962
20	Obv. 26	72	IX	17	first	appearance in the	east	in	Sagittarius		234.537	3.175
20	Obv. 27	72	X	27	last	appearance in the	east	in	Capricorn		275.355	-1.517
20	Obv. 27	72	XII	1	first	appearance in the	west	in	Pisces		336.609	-0.079
20	Obv. 27	72	XII_2	1	last	appearance in the	west	in	Aries		356.683	2.798
20	Obv. 27	72	XII_2	23	first	appearance in the	east		omitted		350.632	-2.342

ADART Vol. VI No.		Observation date (Seleucid Era)									Tropical Longitude	Latitude
22	'Obv.' 13'	76	I	2	first	appearance in the	west	in	Taurus		30.939	1.361
22	'Obv.' 15'	76	V?	21	last	appearance in the	west	in	Virgo		176.464	-2.274
22	'Obv.' 16'	76	VI	24	[first]	appearance in the	east	in	Virgo		171.126	0.735
22	'Obv.' 17'	76	[VII?]	Around the 25	[last]	appearance in the	east	in	Libra		203.895	0.835
22	'Obv.' 17'	76	[IX]	10	first	appearance in the	west	in	Capricorn?		273.646	-1.885
22	'Obv.' 18'	76	XI	24	last	appearance in the	east	in	Aquarius		313.069	-2.187
22	'Obv.' 18'	76	XII	26	first	appearance in the	west	in	Aries		12.685	0.75
24	Line 5'	78	II	17	[last]	appearance in the	east		[…]		56.568	-0.266
27	Obv. 17	[83]	I	11	first	appearance in the	west?	in	Taurus?		22.335	1.043
27	Obv. 19	[83]	III?	26?	[first]	appearance in the	east?		[…]		63.378	-1.68
26	'Obv.' 3'	[83]	V	11	first	appearance in the	west	in	end of Leo		143.763	0.486
27	Obv. 21	[83]	VII	7	first	appearance in the	east?	in	Virgo		163.94	0.944
26	'Obv.' 5'	[83]	VIII	Around the 4	last	appearance in the	east	in	Libra		195.001	1.157
26	'Obv.' 6'	[83]	X	10	last	appearance in the	west	in	Capricorn?		284.084	1.775
26	'Obv.' 6'	[83]	[X]	Around the 24	first	appearance in the	east	in	Capricorn		270.136	3.437
26	'Obv.' 7'	[83]	[XII]	Around the 7	[last]	appearance in the	east		[…]		310.328	-2.158
27	Obv. 25	[83]	XII_2	6	[first]	appearance in the	[west]	in	[Aries]		6.122	0.556
28	'Obv.' 2'	[85]	II	13	…	appearance in the	east		[…]		26.644	-2.833
28	'Obv.' 4'	[85]	VI	18	[last]	appearance in the	east	in	Virgo		159.28	1.835
28	'Obv.' 4'-5'	[85]	VIII	17	[last]	appearance in the	[west]	in	Sagittarius		247.518	-2.113
28	'Obv.' 5'	[85]	IX	12	first	appearance in the	east	in	Sagittarius?		237.597	3.208
35	Obv. 12	94	I	15	last	appearance in the	east	in	Aries		350.782	-2.641
35	Obv. 12-13	94	II	19	[first]	appearance in the	[west]		[…]	(ideal) first on 17	57.586	1.776
35	Obv. 14	94	IV	2	[last]	appearance in the	[west]	in	[Cancer]		102.472	-3.535
35	Obv. 15	94	IV	26	first	appearance in the	east	in	Cancer	(ideal) first on 25	92.482	-2.176
35	Obv. 16	94	VI_2	9	first	appearance in the	west		omitted		202.342	-2.468
35	Obv. 16	94	VI_2	23	[last]	appearance in the	west		omitted		213.943	-2.704
35	Obv. 17	94	VII	12	first	appearance in the	east	in	Libra	(ideal) first on 10	198.461	2.134
35	Obv. 18	94	VIII	21	last	appearance in the	east	in	Sagittarius		241.111	-0.657
35	Obv. 19	94	IX	27	first	appearance in the	west	in	Aquarius		299.469	-1.33

ADART Vol. VI No.		Observation date (Seleucid Era)									Tropical Longitude	Latitude
35	Obv. 20	94	X	Around the 18	last	appearance in the	west	in	Aquarius		319.628	3.27
35	Obv. 20	94	XI	7	first	appearance in the	east	in	Aquarius		306.4	1.843
35	Obv. 21	94	XII	Around the 10	[last]	appearance in the	east	in	Pisces		336.793	-2.489
37	'Obv. 5'	96	I	7	first	appearance in the	west	in	Taurus		23.351	0.98
37	'Obv. 7'	96	[II]	13	last	appearance in the	west	in	Gemini		63.998	-0.192
37	'Obv. 7'	96	III	21	[first]	appearance in the	east	in	Gemini		63.73	-2
37	'Obv. 8'	96	IV	7	last	appearance in the	east	in	Gemini		89.236	1.024
37	'Obv. 8'	96	V	11	first	appearance in the	west	in	end of Leo		151.018	0.028
37	'Obv. 9'	96	VI	Around the 6	last	appearance in the	west	in	end of Virgo		179.283	-3.095
37	'Obv. 9'	96	VII	2	[first]	appearance in the	[east]	in	[Virgo]		166.907	0.596
37	'Obv. 10'	96	IX	18	[first]	appearance in the	[west]	in	[Capricorn]		273.341	-1.787
37	'Obv. 11'	96	[X?]	21?	first	appearance in the	east	in	Capricorn		272.273	3.262
39	Obv. 25	98	XII	22	last	appearance in the	west		[…]		3.443	2.706
44	'Obv.' 16'	[109]	I	6	[first]	appearance in the	west	in	Taurus		32.508	1.547
46	Obv. 17	[114]	I	28	[first]	appearance in the	west		[…]		58.109	1.924
46	Obv. 19	[114]	IV	10	first	appearance in the	east	in	Cancer		93.714	-0.66
50	'Obv. 5'	[122]	I	2	first	appearance in the	west	in	Taurus		31.57	1.342
50	'Obv. 8'	[122]	II	8	last	appearance in the	west	in	Gemini		70.266	-1.063
48	'Obv. 7'	[122]	[X]	15	first	appearance in the	east	in	Capricorn		277.29	2.972
48	'Obv. 8'	[122]	XI	Around the 17	last	appearance in the	east	in	Aquarius		304.461	-1.889
48	'Obv. 9'	123]	I	[…]	first	appearance in the	[west]	in	end of Aries	(ideal) first on 26 of XII in Aries	17.379	1.085
53	'Obv.' 14'	125	I	25	first	appearance in the	east		omitted		17.765	-2.896
53	'Obv.' 14'	125	II	9	[last]	appearance in the	east		[omitted]		39.225	-0.999
53	'Obv.' 15'	125	[III]	[…]	first	appearance in the	west	in	Cancer	(ideal) first on 2	84.717	1.88
53	'Obv.' 16'	125	IV	14	last	appearance in the	west	in	Leo	from the 12 I did not see	137.254	-3.386
53	'Obv.' 16'-17'	125	V	14	[first]	appearance in the	east	in	Leo	(ideal) first on 9	124.982	-0.096
53	'Obv.' 17'	125	VI	Around the 2	last	appearance in the	east	in	beginning of Virgo		151.038	1.867
53	'Obv.' 17'-18'	125	VIII	1	first	appearance in the	[west]	in	Scorpius	(ideal) first on 28 of VII	239.274	-2.349
53	'Obv.' 18'	125	VIII	15	last	appearance in the	west	in	Sagittarius		241.651	0.442
53	'Obv.' 19'	125	VIII	[…]	first	appearance in the	east	in	Scorpius	(ideal) first on 24	230.274	2.889

ADART Vol. VI No.		Observation date (Seleucid Era)									Tropical Longitude	Latitude
53	'Obv.' 20'	125	X	8	last	appearance in the	east	in	Capricorn		271.853	-1.478
53	'Obv.' 20'-21'	125	XI	14	[first]	appearance in the	west	in	Pisces	(ideal) first on 12	336.188	0.279
53	'Obv.' 21'	125	XII	Around the 1	last	appearance in the	west	in	end of Pisces		353.137	3.408
57	Obv.' 25	[135]	III	9	[first]	appearance in the	east	in	Gemini		70.191	-2.081
57	Obv.' 26	[135]	V	Around the 7	first	appearance in the	west	in	Virgo		167.508	-1.015
57	Obv.' 27	[135]	VI	22	[first]	appearance in the	east	in	end of Virgo		174.709	0.897
57	Obv.' 28	[135]	IX	27	[last]	appearance in the	west		[…]		293.519	2.736
57	Obv.' 29	[135]	[X]	12	[first]	appearance in the	east	in	Aquarius		279.988	2.896
57	Obv.' 30	[135]	[XI?]	24	last	appearance in the	east	in	beginning of Pisces		324.967	-2.241
59	Line 4'	137	[II]	Around the 22	[first]	appearance in the	[east]		[omitted]		31.573	-3.389
61	'Obv. 21'-22'	[139]	VIII	[…]	[first]	appearance in the	east	in	Scorpius	(ideal) first on 13	217.629	2.246
61	'Obv 23'	[139]	IX	29	last	appearance in the	east	in	Sagittarius	from 26 not seen	261.991	-1.338
61	'Obv. 24'	[139]	XI?	Around the 27	last	appearance in the	west	in	Pisces		335.804	3.706
61	'Obv. 24'-25'	[139]	XII	20	first	appearance in the	[east]		[…]	(ideal) first on 17	327.003	-0.81
62	Obv.' 14	[140]	[I]	[1]6	last	appearance in the	east	in	Aries		354.651	-2.562
62	Obv.' 14	[140]	II	17?	first	appearance in the	west	in	Gemini		54.121	1.56
62	Obv.' 16	[140]	IV	[…]	last	appearance in the	[west]	in	Cancer	from 28 of III not seen	104.129	-2.591
62	Obv.' 16	[140]	IV	26	[first]	appearance in the	east		[…]		93.449	-2.215
62	Obv.' 17	[140]	V?	17	last	appearance in the	east	in	beginning of Leo		121.432	1.672
62	Obv.' 17-18	[140]	VIII?	9	first	appearance in the	[east]	in	Libra	(ideal) first on 8	201.833	1.461
62	Obv.' 20	[140]	XI	18	[last]	appearance in the	west	in	end of Capricorn		320.319	3.415
68	'Obv.' 13'	146	II	9	first	appearance in the	west	in	Gemini		77.216	2.033
68	'Obv.' 15'	146	[IV?]	[…]	first	appearance in the	[east]		[…]	(ideal) first on 11	102.839	-2.105
68	'Obv.' 16'	146	VII	Around the 11	last	appearance in the	west		omitted		224.333	-1.941
68	'Obv' 16'	146	VII	29	[first]	appearance in the	east	in	beginning of Scorpius	(ideal) first on 27	208.202	2.661
68	'Obv.' 17'-18'	146	[IX]	Around the 5	last	appearance in the	east	in	Sagittarius		246.998	-0.638
68	'Obv.' 18'	146	X	14?	first	appearance in the	west	in	Aquarius		313.032	-0.761
68	'Obv.' 19'	146	[XI?]	27	first	appearance in the	east	in	beginning of Pisces		318.17	0.314
68	'Obv.' 19'	146	XII	23	[last]	appearance in the	east	in	end of Pisces		343.585	-2.613
69	Obv. 20	148	I	26	first	appearance in the	[west]	in	[Tau]rus		41.65	1.769

ADART Vol. VI No.		Observation date (Seleucid Era)									Tropical Longitude	Latitude
69	Obv. 23-24	148	[III?]	[…]	[last]	appearance in the	west	in	Gemini	from the 1 not seen	76.614	-1.388
69	Obv. 24	148	IV	7	first	appearance in the	east	in	Gemini	[(ideal) first] on 4	75.391	-1.471
69	Obv. 25	148	IV?	23	last	appearance in the	east	in	Cancer		103.375	1.466
69	Obv. 25	148	VI	4	first	appearance in the	west	in	Virgo		171.489	-1.224
69	Obv. 25-26	148	VI	[…]	[last]	appearance in the	west	in	beginning of Libra	from the 16 not seen	185.648	-2.686
69	Obv. 26	148	VII	18	first	appearance in the	east	in	beginning of Libra	(ideal) first on 14	176.686	1.542
69	Obv. 28	148	X	5	first	appearance in the	west	in	Capricorn	(ideal) first on 4	284.772	-1.441
69	Obv. 28-29	148	X	[…]	last	appearance in the	west	in	Aquarius	from the 20 not seen	297.575	2.061
69	Obv. 29	148	XI	10	first	appearance in the	east	in	Capricorn	(ideal) first on 8	282.544	2.616
69	Obv. 31-32	148	XII	17	last	appearance in the	east	in	Pisces	from the 14 in the end of Aquarius not seen	320.99	-2.274
69	Obv. 32-33	148	XII_2	23	first	appearance in the	[west]	in	Taurus	(ideal) first on 20 in the end of Aries	29.269	1.749
71	'Obv. 15'	[152]	I	Around the 2	first	appearance in the	east		omitted		354.459	-2.915
71	'Obv. 15'	[152]	I	Around the 20	[last]	appearance in the	east		[omitted]		18.338	-2.145
71	'Obv. 17'	[152]	IV	2	last	appearance in the	[west]		[…]		125.431	-3.386
71	'Obv. 18'	[152]	[IV]	27	first	appearance in the	east	in	end of Cancer		112.753	-1.368
71	'Obv. 19'	[152]	[V?]	Around the 17	last	appearance in the	east	in	Leo		136.13	1.809
71	'Obv. 19'	[152]	VII	Around the 11	[first]	appearance in the	west		[omitted]		220.321	-2.473
71	'Obv. 20'	[152]	VIII	14	first	appearance in the	east	in	Scorpius		217.861	2.781
71	'Obv. 22'	[152]	XI	1	first	appearance in the	west	in	beginning of Pisces		324.273	-0.239
71	'Obv. 23'	[152]	XII	21?	first	appearance in the	east	in	Pisces		333.011	-1.813
73	Obv. 37'	155	V	Around the 5	first	appearance in the	west	in	Virgo?		151.36	0.205
73	Obv. 37'	155	V	Around the 27	[last]	appearance in the	[west]		[…]		179.499	-2.676
73	Obv. 38'	155	VI	28	[first]	appearance in the	east	in	Virgo		170.192	1.022
73	Obv. 40'	155	[IX]	9?	[first]	appearance in the	west	in	[Capricorn]		268.996	-2.05
73	Rev. 1-2	155	[X]	[…]	[first]	appearance in the	east	in	Capricorn	(ideal) first on 14	277.919	3.609
73	Rev. 3	155	XI	28	last	appearance in the	east	in	Aquarius	from the 26 not seen	314.917	-2.204
73	Rev. 4	156	I	1	first	appearance in the	west	in	Aries	(ideal) first on 30 of XII	16.929	1.129
73	Rev. 6	156	[II]	Around the 7	last	appearance in the	west	in	end of Taurus		46.694	-0.689
73	Rev. 6	156	III	13	first	appearance in the	east	in	Gemini		53.745	-1.941

ADART Vol. VI No.		Observation date (Seleucid Era)									Tropical Longitude	Latitude
73	Rev. 7	156	III	Around the 25	last	appearance in the	east	in	Gemini		74.869	0.477
73	Rev. 7	156	IV	24	[first]	appearance in the	west	in	Leo		128.964	1.131
73	Rev. 8	156	V	Around the 26	[last]	appearance in the	west	in	Virgo		167.889	-3.24
74	Obv.' 21-22	156	VI	[…]	first	appearance in the	[east]	in	Virgo	(ideal) first on 23?	154.323	0.184
74	Obv.' 22	156	VII	Around the 17	last	appearance in the	east	in	Libra		181.886	1.57
73	Rev. 10-11	156	IX	11	[first]	appearance in the	[west]	in	[end of Sagittarius]	(ideal) first on 9 in Sagittarius	264.388	-1.91
74	Obv.' 24-25	156	IX?	Around the 24?	last	appearance in the	west	in	Capricorn		274.693	0.683
73	Rev. 12	156	X	Around the 8	first	appearance in the	east	in	Sagittarius		260.91	3.533
73	Rev. 13	156	XI	Around the 22	last	appearance in the	east	in	Aquarius		300.172	-2.001
73	Rev. 13	156	XII	28	first]	appearance in the	[west]	in	[Aries]		6.377	1.208
73	Rev. 15	156	XII_2	Around the 26	last	appearance in the	west	in	beginning of Taurus		27.504	1.445
75	'Obv.' 16'	[159]	III	1	[first]	appearance in the	west	in	Gemini		70.672	1.888
77	Obv. 10	[161]	I	21	first	appearance in the	west	in	Taurus	(ideal) first on 19	42.743	1.717
77	Obv. 14	[161]	III	2	last	appearance in the	west	in	end of Gemini	from 28 of II not seen	78.516	-2.866
77	Obv. 14	[161]	IV	1	first	appearance in the	east	in	Gemini	(ideal) first on 27 of III	74.959	-2.058
77	Obv. 16	[161]	IV?	Around the 16	[last]	appearance in the	[east]		[…]		98.373	1.093
77	Obv. 16	[161]	[V?]	Around the 25	[first]	appearance in the	west		omitted		167.182	-0.65
77	Obv. 17	[161]	VII	14	[first]	appearance in the	east		[…]	(ideal) first on 13	179.336	1.492
77	Obv. 18	[161]	X	1	[first]	appearance in the	west	in	Capricorn	(ideal) first on 28 [of IX]	286.096	-1.471
77	Obv. 19	[161]	XI	4	first	appearance in the	east	in	Capricorn		285.705	2.922
81	'Obv.' 9'	[176]	I	Around the 11	last	appearance in the	west	in	Taurus		42.155	0.266
81	'Obv.' 9'	[176]	II	23	first	appearance in the	east	in	end of Taurus		53.068	-1.591
81	'Obv.' 10'	[176]	[II?]	29	last	appearance in the	east	in	Gemini		63.522	-0.366
81	'Obv.' 10'	[176]	IV	2	first	appearance in the	west	in	Leo	(ideal) first on 1	125.783	1.189
81	'Obv.' 11'	[176]	VI	1	first	appearance in the	east	in	Virgo		150.155	0.337
81	'Obv.' 12'	[176]	VIII	19	first	appearance in the	west	in	Sagittarius	(ideal) first on 18	263.453	-1.793
81	'Obv.' 14'	[176]	XII	5?	first	appearance in the	west	in	Aries		2.788	1.141
82	Obv.' 17	179	II	8	first	appearance in the	west	in	Gemini	(ideal) first on 6	69.245	1.939
82	Obv.' 19	179	III	[…]	last	appearance in the	west	in	end of Cancer	from the 20 not seen	112.866	-3.556
82	Obv.' 19	179	IV	16	[first]	appearance in the	east	in	Cancer		101.792	-1.732

ADART Vol. VI No.		Observation date (Seleucid Era)									Tropical Longitude	Latitude
82	Obv.' 20	179	V	Around the 5	last	appearance in the	east	in	Leo		128.376	1.746
82	Obv.' 20	179	VII	2	first	appearance in the	west		omitted		215.613	-2.716
82	Obv.' 20-21	179	VII	14?	last	appearance in the	west		omitted		222.862	-2.104
86	Obv. 20	190	II	Around the 6	first	appearance in the	<east>		omitted		39.897	-1.906
86	Obv. 20-21	190	II	Around the 20	last	appearance in the	east		omitted		66.845	0.684
86	Obv. 21	190	III	19	first	appearance in the	west	in	Cancer	(ideal) first on 17	108.579	1.664
86	Obv. 22	190	IV	Around the 23	last	appearance in the	west	in	Leo		150.102	-3.151
86	Obv. 22	190	V	24	first	appearance in the	east	in	Leo	(ideal) first on 21	136.906	-0.108
86	Obv. 23	190	VI	12	<last>	appearance in the	east	in	Virgo	from the 12 not seen	161.705	1.87
86	Obv. 23	190	VIII	Around the 8	first	appearance in the	west	in	Sagittarius		247.118	-2.295
86	Obv. 23-24	190	VIII	Around the 23	last	appearance in the	west	in	Sagittarius		256.636	0.202
86	Obv. 24	190	IX	Around the 7	first	appearance in the	east	in	Sagittarius		242.411	3.268
86	Obv. 24	190	X	Around the 13	last	appearance in the	east	in	Capricorn		274.349	-1.208
86	Obv. 25	190	XI	24	first	appearance in the	west	in	Pisces	(ideal) first on 23	345.872	0.331
86	Obv. 26	190	XII	Around the 17	last	appearance in the	west	in	Aries		7.449	3.199
88	'Obv. 8'	[199]	III	29	last	appearance in the	west		[…]		107.162	-3.962
88	'Obv. 10'-11'	[199]	VII	Around the 18	[last]	appearance in the	west		omitted		218.731	-2.512
88	'Obv. 11'	[199]	VIII	8	[first]	appearance in the	east		[…]		202.81	2.375
88	'Obv. 13'	[199]	X	22?	first	appearance in the	west	in	Aquarius	(ideal) first on 21	303.747	-1.264
88	'Obv. 14'	[199]	[XI]	[…]	last	appearance in the	west	in	beginning of Pisces	from the 11 not seen	325.028	2.902
88	'Obv. 14'	[199]	XII	Around the 5	first	appearance in the	east	in	Aquarius		311.369	1.036
88	'Obv. 15'	[199]	XII?	Around the 28	last	appearance in the	east	in	Pisces		330.735	-2.414
92	Obv. 11	[201]	I	4	first	appearance in the			[…]	(ideal) first on 3	31.786	1.362
92	Obv. 13	[201]	II	Around the 11	last	appearance in the	west	in	Gemini		69.25	-1.116
94	Obv.' 2	209	I?	[…]	[last]	appearance in the	west	in	Taurus	from the 10 [not seen]	40.903	1.223
94	Obv.' 3	209	[II]	[…]	first	appearance in the	[east]		[…]	(ideal) first on 20	43.814	-2.651

Appendix K4: Mercury phenomena from the Almanacs and Normal Star Almanacs

Text	Prediction date (Seleucid Era)	Tropical longitude	Latitude

Text		Prediction date (Seleucid Era)				Tropical longitude	Latitude
LBAT 998	Rev. 2'	55	XI	4	Mercury's last appearance in the west in Aquarius	308.082	3.766
LBAT 998	Rev. 4'	55	XI	16	Mercury's first appearance in the east in Aquarius	298.414	2.657
MMA 86.11.369	Obv. 4	70	XII	12	Mercury's first appearance in the west in Aries	7.086	0.81
MMA 86.11.369	Obv. 12	70	I	23	Mercury's last appearance in the west in the Chariot	57.181	-0.649
MMA 86.11.369	Obv. 16	70	II	25	Mercury's first appearance in the east in Gemini	54.64	-2.835
MMA 86.11.369	Rev. 14'	70	III	12	Mercury's last appearance in the east in Cancer	79.139	0.487
BM 40101+	Obv. 9	92	IV	12	Mercury's last appearance in the west in Leo	139.128	-3.626
BM 40101+	Rev. 5	92	X	7	Mercury's last appearance in the east in Capricorn.	275.442	-1.616
LBAT 1008	Rev. 14-15	96	X	8	Mercury's last appearance in the west in Capricorn	285.268	2.541
LBAT 1010	Rev. 7	104	IX	22	Mercury's first appearance in the east in Sagittarius […]	250.996	3.394
BM 40625	Obv. 2	105	I	18	Mercury's first appearance in the east omitted	20.249	-3.022
BM 40625	Obv. 4	105	II	1	Mercury's last appearance in the east omitted	38.927	-1.298
BM 40625	Obv. 12	105	IV	12	Mercury's last appearance in the west in ⌜x⌝	141.702	-4.064
BM 40625	Rev. 2	105	VIII	5	Mercury's last appearance in the west in Sagittarius.	247.61	-0.069
BM 41022+	Obv. 6	106	IV	27	Mercury's first appearance in the east in Cancer	111.346	-1.933
LBAT 1016-18	Rev. 5	107	XI	18	Mercury's last appearance in the west in Pisces.	244.773	-0.799
LBAT 1019	Rev. 5	108	[IX]	20	Mercury's first appearance in the west in Capricorn	358.718	-1.115
LBAT 1020	Obv. 4	111	[II?]	7	Mercury's first appearance in the east omitted	33.894	-2.59
LBAT 1020	Obv. 6	111	[II?]	26	Mercury's last appearance in the east, omitted.	68.721	0.826
LBAT 1020	Obv. 8	111	[III?]	13	Mercury's first appearance in the west in Cancer.	102.897	1.803
LBAT 1020	Obv. 10-11	111	[IV?]	24	Mercury's last appearance in the west […]	151.727	-3.67
LBAT 1020	Obv. 12	111	[V?}	9 (or [1]9?)	Mercury's first appearance in the east in Leo.	137.216	-0.335
LBAT 1020	Obv. 13	111	VI	12	Mercury's last appearance in the east in Virgo.	166.592	1.724
LBAT 1020	Rev. 3	111	XI	20	Mercury's first appearance in the west in Pisces.	343.818	0.112
LBAT 1021	Rev. 6	116	IX	27	Mercury's first appearance in the east in Capricorn	268.162	3.371
LBAT 1022	Rev. 5	120	[XII?]	30	Mercury's last appearance in the east in Pisces	337.855	-2.554
LBAT 1123	Obv. 1	129	I	12	Mercury's first appearance in the west in Taurus	25.009	1.188
LBAT 1123	Obv. 5	129	II	21	Mercury's last appearance in the west in Gemini	60.676	-1.639
LBAT 1123	Obv. 6	129	III	24	Mercury's first appearance in the east in Gemini	62.85	-1.932
LBAT 1123	Obv. 7	129	IV	9	Mercury's last appearance in the east in the end of Gemini	86.828	0.907

Text		Prediction date (Seleucid Era)				Tropical longitude	Latitude
LBAT 1123	Obv. 9	129	V	11	Mercury's first appearance in the west in the end of Leo	146.006	0.375
LBAT 1123	Rev. 4	129	XII_2	7	Mercury's first appearance in the west in Aries	8.781	0.72
LBAT 1029	Obv. 9	146	V	2	Mercury's last appearance in the east in Leo	130.662	1.782
LBAT 1030	Rev. 4	146	VIII	6	Mercury's first (?) appearance in the east in Sagittarius	210.451	2.602
LBAT 1034-5	Obv. 6	157	VIII	10	Mercury's first appearance in the west in Sagittarius	254.834	-1.827
LBAT 1034-5	Obv. 11	157	IX	2	Mercury's first appearance in the east in Sagittarius	245.26	3.249
LBAT 1127	Obv. 7	158	IV	[x+]4	Mercury's last appearance in the west in Leo	126.912	-0.817
LBAT 1034-5	Rev. 15	158	VI	5	Mercury's last appearance in the east in the end of Leo	150.627	1.854
LBAT 1127	Rev. 7	158	[X]	12	Mercury's last appearance in the east in Capricorn	273.039	-1.566
LBAT 1127	Rev. 8	158	[XI]	13	Mercury's first appearance in the west in Pisces	328.365	-0.46
LBAT 1038	Obv. 20	172	V	2	Mercury's first appearance in the east in Cancer	108.037	-2.359
LBAT 1134	Obv. 9	178	V	20	Mercury's first appearance in the east in Leo	117.894	-1.303
LBAT 1134	Obv. 12	178	VI	12	Mercury's last appearance in the east in Leo	145.564	1.864
LBAT 1134	Rev. 1	178	VIII	6	Mercury's first appearance in the west in Scorpio	229.397	-2.546
LBAT 1134	Rev. 2-3	178	VIII	23	Mercury's last appearance in the [west] in the beginning of Sagittarius	237.004	-0.287
LBAT 1136	Obv. 6	179	V	10	Mercury's last appearance in the east in Leo	137.829	1.807
LBAT 1135	Rev. 2	179	XI	11	Mercury's last appearance in the west in Pisces	326.377	3.787
LBAT 1137	Obv. 7	183	III	3	Mercury's first appearance in the east omitted	46.49	-1.758
LBAT 1137	Obv. 8	183	III	13	Mercury's last appearance in the east omitted	64.937	0.191
LBAT 1137	Rev. 4	183	VIII	29	Mercury's first appearance in the west in Sagittarius	255.891	-2.052
LBAT 1137	Rev. 5	183	IX	14	Mercury's last appearance in the west in the beginning of Leo	262.86	0.867
LBAT 1137	Rev. 6	183	IX	27	Mercury's in the east first appearance in Libra	248.718	3.36
LBAT 1137	Rev. 9	183	XI	$10^?$	Mercury's last appearance in the east in the end of Capricorn	291.123	-1.863
LBAT 1137	Rev. 11	183	XII	10	Mercury's first appearance in the west in Pisces	344.666	-0.225
LBAT 1047	Line 15	184	X	5	Mercury's last appearance in the east in Capricorn	278.402	-1.677
LBAT 1047	Line 18	184	XI	7	Mercury's first appearance in the west in Pisces.	334.406	-0.211
LBAT 1051	Obv. 1	188	I	7	Mercury's first appearance in the west [in Tau]rus	28.711	1.267
LBAT 1051	Obv. 8	188	II	13	Mercury's last appearance in the west in Gemini	66.033	-0.947
LBAT 1052	Rev. 5	188	VII	30	Mercury's last appearance in the east in Libra	200.611	1.006
LBAT 1051	Rev. 11	188	X	20	Mercury's first appearance in the east in Capricorn […]	274.169	3.155

Text		Prediction date (Seleucid Era)				Tropical longitude	Latitude
LBAT 1055	Obv. 8	189	II	4	Mercury's [last appearance] in the west in Taurus	46.136	0.859
LBAT 1141	Obv. 4	189	III	12	Mercury's first appearance in the east in the end of Taurus	47.669	-2.638
LBAT 1055	Obv. 23	189	IV	26	Mercury's first appearance in the west in Leo	126.88	1.211
LBAT 1055	Obv. 31	189	V	30	Mercury's last appearance in the west in Virgo	166.663	-3.314
LBAT **1055	Obv. 37-38	189	VI	25	Mercury's first appearance in the east in Virgo	152.889	-0.052
LBAT **1055	Rev. 43	189	VI_2	23	Mercury's last appearance in the east in Libra	184.736	1.364
LBAT **1055	Rev. 48	189	VIII	14	Mercury's first appearance in the west in Sagittarius	262.33	-1.99
LBAT **1055	Rev. 51	189	IX	2	Mercury's last appearance in the west in Capricorn	270.462	2.036
LBAT 1055	Rev. 52-53	189	IX	12	Mercury's first appearance in the east in Sagittarius	259.091	3.503
LBAT 1055	Rev. 58	189	X	26	Mercury's's last appearance in the east in Aquarius	299.731	-2
LBAT 1055	Rev. 63	189	XI	27	Mercury's first appearance in the west in Aries	358.246	0.486
LBAT 1057	Obv. 18	194	IV	4	Mercury in the east […] first appearance	72.932	-2.223
LBAT 1057	Obv. 21	194	IV	23	Mercury's last appearance in the east in Cancer	103.999	1.456
LBAT 1057	Rev. 5	194	X	3	Mercury's first appearance in the west in Capricorn	285.487	-1.454
LBAT 1057	Rev. 6	194	X	20	Mercury's [last appearance] in the west in Aquarius	297.885	2.585
LBAT 1057	Rev. 8	194	XI	8	Mercury's first appearance in the east in Capricorn […]	283.627	2.643
LBAT 1149	Rev. 5	198	$X^?$	16	Mercury's last appearance in the east in the end of Sagittarius	299.555	-1.899
LBAT 1059	Obv. 2	201	I	2	Mercury's first appearance in the west in Taurus	27.679	1.045
LBAT 1059	Obv. 10	201	II	11	Mercury's last appearance in the west in Gemini	69.25	-1.116
LBAT **1059	Obv. 15	201	III	14	Mercury's first appearance in the east in Gemini	66.082	-2.39
LBAT 1059	Obv. 20	201	IV	1	Mercury's last appearance in the east in the beginning of Cancer	93.534	1.089
LBAT **1059	Obv. 26	201	V	5	Mercury's first appearance in the west in Virgo	155.093	-0.035
LBAT **1059	Obv. 30	201	V	27	Mercury's last appearance in the west in Virgo	182.131	-2.88
LBAT **1059	Rev. 37	201	VI	26	Mercury's first appearance in the east in Virgo	171.284	0.995
LBAT 1059	Obv. 37	201	VII	26	Mercury's last appearance in the east in the end of Libra	204.855	0.827
LBAT **1059	Rev. 50	201	IX	13	Mercury's first appearance in the west in Capricorn	277.62	-1.727
LBAT **1059	Rev. 54	201	X	4	Mercury's last appearance in the west in the beginning of Aquarius	289.316	2.883
LBAT **1059	Rev. 70	201	XII	29	Mercury's first appearance in the west in Aries	17.575	1.106
LBAT 1155	Obv. 2	209	I	16	Mercury's last appearance in the west in Taurus	38.799	-0.361
LBAT 1155	Obv. 4	209	II	19	Mercury's first appearance in the east in Taurus	42.598	-2.814

Text		Prediction date (Seleucid Era)				Tropical longitude	Latitude
LBAT 1155	Obv. 7	209	III	5	Mercury's last appearance in the east in Gemini	68.998	0.253
LBAT 1153	Obv. 8	209	III	29	Mercury's first appearance in the west in the […] of Leo	116.768	1.582
LBAT 1153	Rev. 3	209	IX	12	Mercury's first appearance in the east in Sagittarius […]	261.867	2.833
LBAT 1152	Rev. 6	209	[XI?]	2	Mercury's last appearance in the east in the beginning of Aquarius	294.937	-1.908
LBAT 1062	Obv. 6	212	III	21	Mercury's last appearance in the west in Cancer	111.211	-3.008
LBAT 1160	Obv. 3	233	II	22	Mercury's last appearance in the west in the beginning of Cancer	86.753	-2.6
LBAT 1160	Obv. 5	233	III	22	Mercury's first appearance in the morning in the end of Gemini	80.649	-2.068
LBAT 1160	Obv. 10	233	VI	1	Mercury's first appearance in the east [error for west?] omitted?	191.232	-2.463
LBAT 1160	Obv. 12	233	VII	5	Mercury's first appearance in the east in Libra	185.678	1.576
LBAT 1160	Rev. 4	233	[IX?]	21	Mercury's first appearance in the west in Capricorn	290.971	-1.42
LBAT 1160	Rev. 7	233	[X]	28	Mercury's first appearance in the east in the beginning of Aquarius	291.885	2.348
LBAT **1167	Obv. 7	234	IV	1	Mercury's last appearance in the east in the beginning of Gemini	85.185	0.489
BM 32247	Rev. 3	234	IX	18	Mercury's first appearance in the west in Capricorn	262.716	-2.133
BM 32247	Rev. 7	234	X	8?	Mercury's last appearance in the evening in the beginning of Aquarius	287.132	2.951
LBAT 1165	Rev. 9	234	XI	28	Mercury's last appearance in the east in Aquarius?	311.867	-2.146
LBAT 1174	Obv. 3	236	II	6	Mercury's first appearance in the east omitted	30.7	-2.984
LBAT 1174	Obv. 4	236	II	20	Mercury's last appearance in the east omitted	53.065	-0.612
LBAT 1174	Obv. 5	236	III	15	Mercury's first appearance in the west in Cancer	103.814	1.805
LBAT 1174	Obv. 8-9	236	IV	23	Mercury's last appearance in the west in the end of Leo	151.486	-3.284
LBAT 1174	Obv. 10	236	V	21	Mercury's first appearance in the east in Leo	137.993	-0.047
LBAT 1174	Obv. 11-12	236	VI	12	Mercury's in the east last appearance in Virgo	164.095	1.831
LBAT 1174	Rev. 1	236	VIII	8	Mercury's first appearance in the east (error for west) in Sagittarius	249.159	-2.255
LBAT 1174	Rev. 2	236	VIII	23	Mercury's last appearance in the west in Sagittarius	257.247	0.484
LBAT 1174	Rev. 3	236	IX	7	Mercury's first appearance in the east in Sagittarius	242.976	3.276
LBAT 1174	Rev. 6	236	X	23	Mercur last appearance in the east in Capricorn	292.528	-1.963
LBAT 1174	Rev. 8	236	[XI]	23	Mercury's first appearance in the west in Pisces	346.538	0.307
LBAT 1174	Rev. 9-10	236	XII	27	Mercury's last appearance in the west in Aries	3.422	1.421
LBAT *1179-80	Obv. 5-6	245	III	22	Mercury's last appearance in the west in ⌜Cancer⌝	109.289	-2.646
LBAT *1179-80	Obv. 8	245	IV	22	Mercury's first appearance in the east in Cancer.	99.229	-1.573
LBAT *1179-80	Obv. 10	245	V	12	Mercury's last appearance in the east in Leo	127.579	1.751

Text		Prediction date (Seleucid Era)				Tropical longitude	Latitude
LBAT *1179-80	Obv. 13	245	VII	5	Mercury's' [first appearance in the west omitted	209.647	-2.597
LBAT *1179-80	Obv. 13-14	245	VII	15	Mercury's last appearance in the west omitted	218.65	-2.759
LBAT *1179-80	Rev. 15-16	245	VIII	8?	[Mercu]ry's first appearance in the east in the end of Libra	203.685	2.476
LBAT *1179-80	Rev. 17	245	IX	10?	Mercury's last appearance in the east in ⌜Sagittarius⌝	238.141	-0.153
LBAT *1179-80	Rev. 20	245	X	17?	Mercury's first appearance in the west in 'Aquarius⌝	299.026	-1.61
LBAT *1179-80	Rev. 24	245	XII	20+x	Mercury's last appearance in the east in ⌜Pisces⌝	323.966	-1.963
LBAT *1181	Obv. 3	246	II	8?	Mercury's first appearance in the west in Taurus.	46.509	1.548
LBAT *1181	Obv. 5	246	III	15	Mercury's last appearance in the west in Cancer	90.256	-1.701
LBAT *1181	Obv. 12	246	VI	29	[Mercury's] first appearance in the west omitted.	194.955	-2.592
LBAT *1181	Obv. 15	246	VII	1	[Mercury's] first appearance in ⌜the east⌝ in Libra.	188.544	1.52
LBAT 1182	Obv. 5	247	III	12	Mercury's first appearance in the east in Gemini	65.987	-2.643
LBAT 1182	Obv. 6	247	III	28	Mercury's last appearance in the east in Gemini	90.159	0.776
LBAT 1183	Rev. 3	247	IX	3	Mercury's first appearance in the west in Capricorn	250.286	-1.486
LBAT 1183	Rev. 6	248	X	26	Mercury's last appearance in the west in Capricorn	269.451	0.573
LBAT 1183	Rev. 12	248	XII2	24	Mercury's last appearance in the west in Taurus	42.135	2.649
LBAT 1188	Obv. 4	300	II	17	Mercury's last appearance in the west in Gemini	63.285	0.007
LBAT 1188	Obv. 6	300	III	23	Mercury's first appearance in the east in Gemini	61.979	-2.388
LBAT **1191-2	Obv. 3	303	V	23	Mercury's first appearance in the east in Cancer	118.77	-1.001
LBAT 1195	Obv. 3	305	II	3 var: 5	Mercury's first appearance in the west in the beginning of Gemini	50.193	1.603
LBAT 1195	Obv. 5	305	III	13	Mercury's last appearance in the west in Cancer	94.463	-2.326
LBAT 1195	Obv. 7	305	IV	16	Mercury's in the east in […] first appearance	89.165	-1.295
LBAT 1195	Obv. 9	305	V	2	Mercury's last appearance in the east in Cancer	113.64	1.504
LBAT 1195	Obv. 12	305	VI	21	Mercury's first appearance in the east (err for west), omitted	193.765	-2.22
LBAT 1195	Obv. 13	305	VII	5	Mercury's last appearance in the west omitted	206.644	-3.065
LBAT 1195	Obv. 14	305	VII	17	Mercury's last (err for first) appearance in the east in Libra	201.998	-1.127
LBAT 1194	Rev. 7	305	X	12	Mercury's first appearance in the west in the beginning of Aquarius	294.141	-1.49
LBAT 1195	Rev. 6	305	XI	21	Mercury's first appearance in the east in in Aquarius	298.493	1.927
LBAT 1195	Rev. 9	305	XII	25	Mercury's last appearance in the east in Pisces	331.566	-2.4
LBAT 1195	Rev. 12	305	XII2	29	Mercury's first appearance in the west in Taurus	38.126	1.555
MM 86.11.354	Obv. 2	342	I	23	Mercury's (first appearance in the east in Aries)	15.044	-3.205

Text		Prediction date (Seleucid Era)				Tropical longitude	Latitude
MM 86.11.354	Obv. 3	342	II	15	Mercury's [last appearance in the east in Aries]	53.548	0.064
MM 86.11.354	Obv. 8	342	V	11?	Mercury's first appearance in the east in Leo	126.528	-0.739
MM 86.11.354	Obv. 9	342	VI	1?	Mercury's last appearance in the east in Virgo	151.481	1.886
MM 86.11.354	Rev. 3'	342	IX	12	Mercury's last appearance in the east in Capricorn	280.57	-1.75
MM 86.11.354	Rev. 5'	342	X	8	Mercury's first appearance in the west in Capricorn	273.622	-1.445
MM 86.11.354	Rev. 6'	342	XI	9	Mercury's first appearance in the west in Pisces	329.061	-0.711
BM 45982	Obv. 1	355	I	16	Mercury's first appearance (in the east) in Aries	15.819	-3.314
BM 40083	Obv. 3	372	II	12	Mercury's last appearance in the west in Gemini	70.357	-1.393
BM 40083	Obv. 8	372	V	10	Mercury's first appearance in the west in Virgo	161.125	-0.425
DCT	Obv.5	385	III	12	Mercury's first appearance in the east in Gemini	71.558	-2.069
DCT	Rev. 1'	385	IX	5?	Mercury's first appearance in the west in Capricorn	272.433	-2.062
DCT	Rev. 7'	385	XII	26	Mercury's first appearance in the west in Aries	20.127	1.018

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