Did the division of the year by the Babylonians into twelve months lead to the adoption of an equal twelve-sign zodiac in Hellenistic astrology?

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Abstract

This dissertation considers the arguments that Hellenistic astrology imposed a logical order on a somewhat more chaotic astrological paradigm inherited from the Babylonians. In particular, it explores whether the precise thirty degree zodiac signs of Hellenistic astrology were a Hellenistic innovation, or whether they naturally arose out of a Babylonian desire to divide the sky into twelve segments in a consistent fashion in accordance with the Babylonian concept of dividing time into an ideal year of twelve months. This dissertation draws on existing literature in this area, but also incorporates original research based on Babylonian and early Hellenistic source material.

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I would also like to thank astrologer and author Judy Hall for her time and kindness in providing me with access to her library.

Statement of Originality

I declare that this dissertation represents my own work, except where due acknowledgement is made, and that it has not been previously included in a thesis, dissertation or report submitted to the University or any other institution for a degree, diploma or other qualification.

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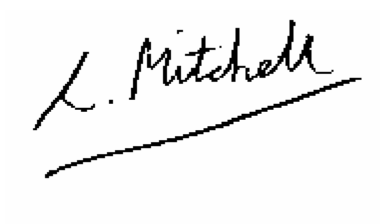

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Introduction

This dissertation is written with a view to contributing to scholarly debate about the notion that science was primarily a Greek development, challenging this viewpoint. It considers the astronomical and astrological paradigms of the Babylonians from about 1000 BCE and of the later Hellenistic tradition, and examines the extent of cultural transmission of concepts from Babylonian cosmology to Hellenistic astrology. This dissertation also challenges the notion that Hellenistic astrology was responsible for rationalising the earlier Babylonian paradigm by innovations including the equal twelve-sign zodiac, and considers whether this concept of the zodiac had been developed in Babylonian astrology prior to its adoption by Hellenistic astrology.

There is a body of previous literature on Babylonian and Hellenistic astrology, including the cultural transmission between them, but much of this concentrates on the mathematical methods used and makes only passing reference to the development of the zodiac, as shall be examined in the 'Review of previous literature' section.[1] This dissertation focuses specifically on the development of the zodiac, and the research that I undertook to examine the Babylonian contribution is based upon relevant Babylonian texts and matching the descriptions in those texts to the actual positions of stars at the time those texts were written, using astronomical software. In order to do this, and to be able to compare the Babylonian and Hellenistic models, it is necessary to be able to date these texts accurately and to understand the terminology used within them. These particular problems are not clear-cut, and there are a number of methodological issues that arose from this research, which are covered in detail in the 'Methodology' section.

[1] See for example, Neugebauer, O., *History of Ancient Mathematical Astronomy*, Part One (Berlin: Springer-Verlag, 1975) [hereafter Neugebauer, *HAMA*]

There seems to be a paucity of information in the available literature as regards the development of the zodiac, and there is an underlying assumption that one can either have a chaotic, irregular constellation-based method of dividing the sky, or a neat mathematical logical division, which will be explored further in the 'Zodiac and constellations' section. It will be argued that the concept of using observations to develop a primarily visual astrology is not necessarily incompatible with the more abstract concept of dividing the sky into equal portions, and the idea that a visual based astrology might also have a basis in "ordered" mathematics will be explored. As shall be demonstrated, although the Greeks were interested in imposing order, the Babylonians were also adept mathematicians.[2] The relationship between astrology in Babylonia and the need for a calendar will be investigated, and the question of whether the original visual system may have been based on the desire to divide the night sky based on equal portions, of time if not of space, will be considered in further detail. The issue of whether the concept of an equal twelve-sign zodiac was present in Babylonian astrology, and whether this concept was adopted by Hellenistic astrology, will be considered by analysing the way that the year was divided up by the Babylonians, and how the Babylonian texts related the division of the year into a division of the sky. The areas of sky delineated by these Babylonian texts will then be compared both to the constellations delineated in Hellenistic astrology, and to the equal zodiacal signs used in Hellenistic astrology, to see to what extent the similarities and differences provide clues regarding the transmission of Babylonian concepts of the zodiac into the Hellenistic model.

[2] See for example Neugebauer, *HAMA* and other arguments in this dissertation

Review of previous literature

The idea that Hellenistic astronomy was an attempt to improve and impose order on a more chaotic Babylonian astrology is implied by Neugebauer:

> In the extant texts from the Hellenistic period almost all methods appear fully developed. On the other hand it is virtually certain that they did not exist at the end of the Assyrian period. Thus one must assume a rather rapid development during the fourth or fifth century B.C. The same two centuries witness also the first steps in Greek astronomy.[3]

This view is disputed by Rochberg:

> Until the relatively recent turn away from the pervasive influence of the logical positivists on historians of science, when the model of western science provided the standard against which all other sciences would be judged, the ancient Greeks were assumed to be the inventors of science… Despite the acknowledgement of an intellectual transmission from Babylonia to the Greeks, when it came to general histories of science, Babylonian learning…would be contrasted with Greek "knowledge" in one of two ways. What the eastern ancients "knew" was categorized either as mere craft, developed out of practical necessity, or as theological speculation not anchored by logical, causal, or rational inquiry into physical phenomena.[4]

[3] Neugebauer, *HAMA*, p.4
[4] Rochberg, Francesca, *The Heavenly Writing* (Cambridge: Cambridge University Press, 2004) [hereafter Rochberg, *Heavenly Writing*], pp.15-16

While Rochberg challenges this view, she nevertheless claims that there is ‘no chronological overlap’ between Babylonian and Greek astrology, a claim that will be examined in this dissertation and challenged.[5]

There is a perception that the Greeks “invented” science. Professor Sir Roger Penrose is a renowned mathematician and cosmologist whose recent book, The *Road to Reality*, outlines the mathematical and physical laws governing the universe.[6] It begins with a fanciful prologue, in which Penrose imagines the beginnings of science as the term is understood today, starting with the tale of ‘Am-Tep’, a craftsman living thousands of years ago who experiences a terrifying earthquake and wonders why the patterns of stars in the heavens were unchanged following such an event, and finishing with the story of ‘Amphos’, a thousand years after the event:

> One clear night, Amphos looked up at the heavens, and tried to make out from the patterns of stars the shapes of those heroes and heroines who formed constellations in the sky. To his humble artist’s eye, those shapes made poor resemblances. He could himself have arranged the stars far more convincingly. He puzzled over why the gods had not organized the stars in a more appropriate way? As they were, the arrangements seemed more like scattered grains randomly sowed by a farmer, rather than the deliberate design of a god. Then an odd thought overtook him: Do not seek for reasons in the specific patterns of stars, or of other scattered arrangements of objects; look, instead, for a deeper universal order in the way that things behave…

[5] Rochberg, Francesca, “Babylonian Horoscopes”, *Transactions of the American Philosophical Society For Promoting Useful Knowledge* Vol 88 Pt 1 (Philadelphia: American Philosophical Society, 1998) [hereafter Rochberg, “Babylonian Horoscopes”], p.2
[6] Sir Roger Penrose is Emeritus Professor of Mathematics at the University of Oxford, http://www.ukwhoswho.com/view/article/oupww/whoswho/U30531/PENROSE_Sir_Roger accessed 29 April 2008

> Amphos became convinced that without precision in the underlying laws, there could be no order in the world, whereas much order is indeed perceived in the way that things behave. Moreover, there must be precision in our ways of thinking about these matters if we are not to be led seriously astray.
>
> It so happened that word had reached Amphos of a sage who lived in another part of the land, and whose beliefs appeared to be in sympathy with those of Amphos. According to this sage, one could not rely on the teachings and traditions of the past. To be certain of one's beliefs, it was necessary to form precise conclusions by the use of unchallengeable reason. The nature of this precision had to be mathematical — ultimately dependent on the notion of number and its application to geometric forms. Accordingly, it must be number and geometry, not myth and superstition, that governed the behaviour of the world.
>
> As Am-tep had done a century and a millennium before, Amphos took to the sea. He found his way to the city of Croton, where the sage and his brotherhood of 571 wise men and 28 wise women were in search of truth. After some time, Amphos was accepted into the brotherhood. The name of the sage was Pythagoras.[7]

Pythagoras of Samos lived in the sixth century BCE, and the reason for Penrose invoking his name in his prologue is because of a widespread view that Pythagoras was the first real mathematician, described as a 'Greek philosopher and mystic who, with his followers, seems to have been the first to take mathematics seriously as a study in its own right as opposed to being a collection of formulae for practical calculation'.[8] Penrose agrees with this analysis, saying:

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[7] Penrose, Roger, *The Road to Reality* (London: Vintage, 2005) [hereafter Penrose, *Road to Reality*] pp.4-5
[8] Clapham, C. & Nicholson, J., *The Concise Oxford Dictionary of Mathematics* (Oxford: OUP, 2005) accessed online 28 March 2008 http://www.oxfordreference.com/views/ENTRY.html?subview=Main&entry=t82.e2311

> Although mathematical truths of various kinds had been surmised since ancient Egyptian and Babylonian times, it was not until the great Greek philosophers Thales of Miletus (c.625-547 BC) and Pythagoras of Samos (c.572-497 BC) began to introduce the notion of *mathematical proof* that the first firm foundation stone of mathematical understanding – and therefore of science itself – was laid.[9]

Penrose's prologue, and analysis of Pythagoras' importance, implying that although cultures prior to the Greeks had observed natural phenomena and noticed a structure in them it was the Greeks who first tried to impose systematic order as a way of explaining them, exemplifies Western thought. Indeed, a history of mathematics written by Kline baldly states: 'Mathematics as an organized, independent, and reasoned discipline did not exist before the classical Greeks of the period from 600 to 300 B.C. entered upon the scene'.[10] Chapman, describing Mesopotamian sky myths, writes that they were 'attempts by people living 4,000 years ago to make sense of order and disorder through a series of stories' and claims that 'the Greek philosophers were motivated to find order and meaning in the world and to explain why things changed'.[11]

This exemplifies what Hodgkin calls 'Eurocentrism':

> If we count as the 'European' tradition one which consists *solely* of the ancient Greeks and the modern Europeans – and we shall soon see how problematic that is – a glance

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[9] Penrose, *Road to Reality*, pp.9-10
[10] Kline, Morris, *Mathematical Thought from Ancient to Modern Times Vol 1* (New York: OUP US, 1990), [hereafter Kline, *Mathematical Thought*], p.3
[11] Chapman, Allan, *Gods in the Sky: Astronomy from the Ancients to the Renaissance* (London: Channel 4 Books, 2002), p.41

> through many major texts in the history of mathematics showed either ignorance or undervaluing of the achievements of those outside that tradition.[12]

Pingree names this narrow outlook ‘Hellenophilia’ and describes it as ‘pernicious’:

> I have embraced the word employed in the title of this article, “Hellenophilia,” as it is a most convenient description of a set of attitudes that I perceive to be of increasing prevalence within the profession of the history of science, and which I believe to be thoroughly pernicious.[13]

He goes on to point out that the viewpoint that the Greeks ‘invented science’ is a Western one, informed by ‘cultural myopia’ rather than an objective statement of fact:

> A Hellenophile suffers from a form of madness that blinds him or her to historical truth and creates in the imagination the idea that one of several false propositions is true. The first of these is that the Greeks invented science; the second is that they discovered a way to truth, the scientific method, that we are now successfully following; the third is that the only real sciences are those that began in Greece; and the fourth (and last?) is that the true definition of science is just that which scientists happen to be doing now, following a method or methods adumbrated by the Greeks, but never fully understood or utilized by them.

[12] Hodgkin, Luke, *A history of mathematics from Mesopotamia to Modernity* (New York: OUP US, 2005), [hereafter Hodgkin, *Mesopotamia to Modernity*], p.12

[13] Pingree, David, “Hellenophilia versus the History of Science”, *Isis*, Vol. 83, No. 4. (Dec., 1992), [hereafter Pingree, “Hellenophilia”] p. 554

> Hellenophiles, it might be observed, are overwhelmingly Westerners, displaying the cultural myopia common in all cultures of the world but, as well, the arrogance that characterized the medieval Christian's recognition of his own infallibility and that has now been inherited by our modern priests of science.
>
> Intellectually these Western Hellenophiles are still living in the miasma that permeated Europe until the nineteenth century, before the discovery of Sanskrit and the cracking of cuneiform destroyed such ethnocentric rubbish; such persons have simply not been exposed to the knowledge they would need to arrive at a more balanced judgment.[14]

Despite the assertions mentioned previously that mathematics as a discipline in its own right was a Greek invention, there is a consensus that arithmetic methods were developed by the Mesopotamians. Even Kline, quoted earlier as implying that the Greeks invented mathematics, entitles the first chapter of his book on mathematics 'Mathematics in Mesopotamia' and he dates the beginning of arithmetic methods in Mesopotamia to around 2000 BCE.[15]

Arithmetic, and the ability to perform calculations, can be argued to be a necessary pre-requisite for the practice of mathematical astronomy. Kline, again promoting the idea of Greek supremacy in this science, compares the role of mathematics in Greek and Mesopotamian astronomy:

> Because the connection between mathematics and astronomy became vital from Greek times on, we shall note what the Babylonians knew and did in astronomy… The

[14] Pingree, "Hellenophilia", p.555

> astronomy of the Akkadian period was crude and qualitative; the development of mathematics preceded the development of any significant astronomy. In the Assyrian period (about 700 B.C.), astronomy did begin to include mathematical description of phenomena and a systematic compilation of observational data. The use of mathematics increased in the last three centuries B.C. and was directed especially to the study of lunar and planetary motion.[16]

Neugebauer also acknowledges the role of Mesopotamian mathematics in astronomy, while considering the Greeks to have advanced the subject, culminating with the later Hellenistic writer Claudius Ptolemy:

> There originated in Mesopotamia arithmetical methods for very accurate predictions of lunar and planetary phenomena. Perhaps inspired by these successes, but only in a very small measure depending upon them, cinematic models were developed by Greeks, notably by Apollonius, around 200 B.C. Careful systematic observations by Hipparchus (about 150 B.C.) made it clear, however, that the actual motions were more complicated and that further progress would not be easy. Indeed, only after much groping in the dark, about two centuries later (about A.D. 100) the important tool of spherical astronomy was put on a sound mathematical basis by Menelaos, while a satisfactory planetary theory and an improved theory for the lunar motion had to wait until Ptolemy (about 150 A.D.). His monumental work remained the foundation for all mathematical astronomy until Kepler (around 1600).[17]

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15 Kline, *Mathematical Thought*, p.3 & 5
16 Kline, *Mathematical Thought*, p.11
17 Neugebauer, *HAMA*, p.2

Ptolemy was a Greek living in Alexandria in the second century BCE. His major works were *Almagest* and *Tetrabiblos*.[18] *Almagest* is primarily a textbook of mathematical astronomy, while *Tetrabiblos* is a book on astrology. In contemporary culture, these are seen as two very different subjects; the *Dictionary of Astronomy* defines astronomy as 'measuring the positions and movements of celestial bodies'.[19] Astrology, on the other hand, is defined as a 'pseudoscience':

> The supposed influence of the relative positions of the planets on people's personalities and events in their lives. In its modern form astrology is a pseudoscience, but in ancient times astrology and astronomy were intertwined. Often, the motive for keeping observational records was astrological.[20]

However, the definition here admits that the two subjects were seen as intertwined, so it is not surprising that Ptolemy should have written on both topics.

The idea that the Babylonians developed mathematical techniques for predicting essentially visual solar and lunar phenomena while the Greeks developed the concept of a formal mathematical model of spherical geometry that provided a complete theory of the movement of celestial bodies has led to an impression that there was something of a jump from a visual, chaotic, loose Babylonian astrology to a rigid, organised Greek astrology, particularly in those regular, logical elements such as the division of the zodiac. Neugebauer, for example, makes the claim that 'the main structure of astrological theory is undoubtedly Hellenistic', although

[18] Ptolemy Claudius, *Ptolemy's Almagest* (trans. Toomer, G. J., London: Duckworth, 1984) [hereafter Ptolemy, *Almagest*]. Ptolemy, Claudius (Trans. Robbins, F. E., Loeb Classical Library), *Tetrabiblos* (Cambridge, Mass.: Harvard University Press, 2001) [hereafter Ptolemy, *Tetrabiblos*]

[19] Ridpath, Ian, *A Dictionary of Astronomy*.(Oxford: OUP, 2007) [hereafter Ridpath, *Dictionary of Astronomy*], entry for "astronomy". accessed online 1 April 2008 http://www.oxfordreference.com/views/ENTRY.html?subview=Main&entry=t80.e305

Neugebauer certainly recognises that this division is not clear-cut, as will be examined later in this dissertation.[21]

However, it will be argued that the development of astrology and astronomy in both Greece and Mesopotamia does not appear to support this assumption, and the ‘Cultural transmission’ section will argue that there was considerable cultural crossover. Ptolemy certainly makes references to his predecessors, the Babylonian astronomers, as ‘the Chaldaeans’ in Tetrabiblos, such as when he talks about the Egyptian and Chaldean systems for dividing a zodiac sign into “terms”, complaining that the Egyptian method ‘does not at all preserve the consistency either of order or of individual quality’, while ‘the Chaldaean method involves a sequence, simple, to be sure, and more plausible’.[22] Some modern commentators consider the fact that Ptolemy wrote about both mathematics and astrology to be evidence that the purity of Greek logical thought was being sullied by earlier concepts. Boyer, writing on Ptolemy, says:

> No account of Ptolemy’s work would be complete without mention of his *Tetrabiblos*… Greek authors were not always the rational and clear-thinking men they are presumed to have been. The *Almagest* is indeed a model of good mathematics and accurate observational data put to work in building a sober scientific astronomy; but the *Tetrabiblos*… represents a kind of sidereal religion to which much of the ancient world had succumbed. With the end of the Golden Age, Greek mathematics and philosophy became allies of Chaldean arithmetic and astrology, and the resulting pseudo-religion filled the gap left by repudiation of the old mythology. Ptolemy seems

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[20] Ridpath, *Dictionary of Astronomy*, entry for “astrology” accessed online 1 April 2008 http://www.oxfordreference.com/views/ENTRY.html?subview=Main&entry=t80.e291

[21] Neugebauer, O., *The Exact Sciences in Antiquity* 2nd ed. (Providence, RI: Brown University Press, 1957), p.80

[22] Ptolemy, *Tetrabiblos*, I.20, p.91 & I.21, p.99

> to have shared the prejudices of his time; in the *Tetrabiblos* he argued that one should not, because of the possibility of error, discourage the astrologer any more than the physician. The further one reads in the work, the more dismayed one becomes, for the author showed no hesitation in accepting the superstition of his day.[23]

Although the idea that the Greeks "invented science" has been challenged, the legacy of Greek thought pervades contemporary society, especially in the way that scientists view the world. The atheist biologist Richard Dawkins claims that scientific 'truth' is superior to other claims of truth, especially religious ones:

> How should scientists respond to the allegation that our 'faith' in logic and scientific truth is just that – faith – not 'privileged' (favourite in-word) over alternative truths? A minimal response is that science gets results.[24]

Penrose identifies the Greek method of enquiry – both from Pythagoras and later from Plato – as being at the heart of what modern mathematicians refer to as 'truth'. Unlike Dawkins' unquestioning acceptance of this truth, Penrose accepts that there is a valid question to be asked whether Plato's mathematical world, the world of mathematical propositions and scientific method, truly exists, although Penrose does appear to come down in favour of that world being objectively true:

> But does the Platonic mathematical world actually exist, in any meaningful sense? Many people, including philosophers, might regard such a 'world' as a complete fiction – a product merely of our unrestrained imaginations. Yet the Platonic

[23] Boyer, Carl, *A History of Mathematics* (New York: Wiley, 1989), p.171

> viewpoint is indeed an immensely valuable one… it provides us with the blueprint according to which modern science has proceeded ever since.[25]

Plato's writings such as *Timaeus* describe the cosmos as being constructed a 'Living Creature, one and visible, containing within itself all the living creatures which are by nature akin to itself'.[26] Later in *Timaeus*, Plato describes the cosmos as 'a whole and perfect body… in the midst thereof He set the Soul… and generated it to be a blessed God.'[27] In these passages, which the Penguin translation describes as the 'soul of the world', he appears to be writing from a metaphysical religious perspective.[28] However, the Greek idea of absolute truth and the abstraction of Platonic forms of which Penrose speaks, leads to scientific reductionism as espoused by Dawkins in his polemic against religion, *The God Delusion*:

> An atheist in this sense of philosophical naturalist is somebody who believes there is nothing beyond the natural, physical world, no supernatural creative intelligence lurking behind the observable universe, no soul that outlasts the body and no miracles – except in the sense of natural phenomena that we don't yet understand. If there is something that appears to lie beyond the natural world as it is now imperfectly understood, we hope eventually to understand it and embrace it within the natural.[29]

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24 Dawkins, Richard, *A Devil's Chaplain: reflections on hope, lies, science and love* (Boston, MA: Mariner, 2004), p.14

25 Penrose, *Road to Reality*, p.12

26 Plato (Trans. Bury, R. G., Loeb Classical Library), *Plato IX: Timaeus, Critias, Cleitophon, Menexenus, Epistles* (Cambridge, Mass.: Harvard University Press, 2005) [hereafter Plato, *Plato IX: Timaeus*] 30.D p.57

27 Plato, *Plato IX: Timaeus* 34.B p.65

28 Plato (Trans. Lee, Desmond), *Timaeus and Critias* (London: Penguin Classics, 1977), p.46

29 Dawkins, Richard, *The God Delusion* (London: Bantam, 2006) p.7

Indeed, Penrose himself, although apparently believing in the reality of Platonic truth, wrote a review praising a book about atheism as 'a wonderful source of ammunition for those who, like me, hold to no religious doctrine'.[30]

Babylonian science, on the other hand, considered the movement of stars and planets to be what Campion calls 'the writing of the celestial deities' pointing out that 'Science and religion were the same, and the Babylonians lacked a distinction between what we identify as two ways of knowing. Science, if you like, was designed to understand the divine'.[31] If this view is correct, then Babylonian science can be said to have its own internal logic but this is arguably a different sort of logic to that espoused in the earlier quotes by Penrose and others where they suggest that contemporary science and scientific method are based on a Greek worldview, and it is important to beware of reading Babylonian texts through this particular Greek filter.

There are various papers which do address the development of the zodiac – notably Rochberg's "Babylonian Horoscopes" already referred to, and "The Thirty Six Stars" by van der Waerden.[32] However, references to the zodiac are generally sparse and offered as part of a wider discussion. In this dissertation, original source texts will also be considered, with special reference to the Babylonian text MUL.APIN.[33]

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[30] Quoted on the Richard Dawkins website, "Atheists top book charts by deconstructing God" http://richarddawkins.net/article,248,Atheists-top-book-charts-by-deconstructing-God,Jamie-Doward accessed 8 April 2008

[31] Campion, Nicholas, *Astrology, History and Apocalypse* (London: CPA Press, 2000) [hereafter Campion, *Apocalypse*], p.11

[32] van der Waerden, B. L., "Babylonian Astronomy II, The Thirty-Six Stars", *Journal of Near Eastern Studies*, Vol. 8, No. 1. (Jan 1949) [hereafter van der Waerden, "36 stars"], pp. 6-26.

[33] Hunger, H. & Pingree, D., *MUL.APIN, an astrological compendium in Cuneiform*, Archiv für Orientforschung, Beiheft 24,1989 (Horn, Austria: Verlag F. Berger & Söhne Gesellschaft M.B.H., 1989) [hereafter Hunger & Pingree, *MUL.APIN*]

Concepts

This dissertation will examine early indications of the zodiac, and suggest how this may have developed into the zodiac used in Hellenistic astrology. In addition to examining previous work written on the topic of the zodiac, several original Babylonian and Greek texts will be analysed, and the methodological issues explored in the 'Methodology' section. Before addressing these areas, it is useful to define the concepts being covered. Much of the research focuses on how the Babylonians and the Greeks divided up the night sky and measured this with reference to the appearance of the night sky on specific dates, and so three concepts will be introduced: the method of dividing up the year by means of a calendar; the method of identifying particular areas of the sky using constellations and a zodiac; and the problems encountered in undertaking the research than can highlight ambiguities in the way that the division of the year and the sky is done.

Calendars

Two cycles that are very obvious to observe are the solar cycle with the regular turn of the seasons, and lunar with the phases of the Moon. Myths about the Sun and Moon occur in most cultures.[34] It is very difficult to date these, but the prevalence of them in cultures with a long oral tradition, such as this story from Australia, suggests that lunar cycles have been observed for a long time:

> But Nullandi the Happy Man went up into the sky, to the home of Baiame, where the Great Spirit turned him into the round and shining moon. Nullandi turned the darkness

> of the nights to silver light, and even when he waned and became as thin as a sliver of bark, men knew that he would grow again, just as their own spirits might die for a little while, and then come to life and live for ever.[35]

By the second millennium BCE, celestial omen texts in Mesopotamia concern lunar eclipses and in order to record when an observation took place and where in the heavens it was observed, two concepts are required: the development of a calendar to describe the time an observation occurred, and a notation to describe the location of a celestial body in the sky.[36]

The calendar in use in most of the Western world today derives from the Roman calendar. The idea of a 365-day year, with a leap year every four years, was introduced by Julius Caesar in 46 BCE, and the calendar deriving from this is called the Julian Calendar.[37] The reason for the reform was the haphazard way in which the existing calendar slipped against the seasons, so that it was almost two months out by 46 BCE. Duncan explains the reform:

> To bring the calendar back in alignment with the vernal equinox, which was supposed to occur by tradition on 25 March, Caesar also ordered two extra intercalary months added to 46 BC… To round out his calendar reforms, Caesar… reorganized the lengths of the months to add in the ten days required to bring the year from 355 to 365 days, arranging them to create a calendar of 12 alternating 30- and 31-day months,

[34] See for example Sproul, B, *Primal Myths* (London: Rider, 1979) pp.31, 41, 117, 157, 181, 200, 305 as examples of solar and lunar myths across the world.
[35] "The Blue Fish and the Moon", from Reed, A. W., *Aboriginal Stories of Australia* (Chatswood, NSW: Reed, 1980), pp49-51
[36] Koch-Westenholz, Ulla, *Mesopotamian Astrology* (Copenhagen: Museum Tusculanum Press, 1995), [hereafter Koch-Westenholz, *Mesopotamian Astrology*], p.36
[37] Ridpath, *Dictionary of Astronomy*, entry for "Julian calendar" accessed online 2 April 2008 http://www.oxfordreference.com/views/ENTRY.html?subview=Main&entry=t80.e1979

with the exception of February, which under Caesar's system had 29 days in a normal year and 30 in a leap year.[38]

This appears to have been a successful attempt to align the calendar with the solar year, and so is a solar calendar. In the calendar in use in the West today, the new year starts in the same season each year – winter.

Other calendars in use today are entirely lunar, notably the Islamic calendar. Until 1999, each new Islamic month was declared to start on the first sighting of the new (crescent) Moon at Mecca. This visual, and not always accurate, method was amended to a more astronomical definition which still did not obtain universal agreement, and so since August 2003 a very precise definition of the first day of the month has been used: namely that 'the geocentric conjunction [of Sun and Moon] occurs before sunset [at the coordinates of the Al-Haram Mosque at Mecca], and the Moon sets after the Sun'.[39] This technical change does not alter that fact that is still entirely a lunar calendar, though, so that Islamic months such as Ramadan occur at different times each year. For example, 1 Ramadan 1427 in the Islamic calendar corresponds to a date of 23 September 2006, 1 Ramadan 1428 fell on 12 September 2007, and this slippage of around 11 days a year continues indefinitely, so that 1 Ramadan 1410 fell on 27 March 1990.[40]

Others are a combination of the two, such as the Jewish calendar where months start on a New Moon but are adjusted to make sure the new year happens at roughly the same time each year:

[38] Duncan, David, *The Calendar* (London: Fourth Estate, 1998) [hereafter Duncan, *Calendar*], p.46

[39] Paper presented by Dr. Zaki Al-Mostafa of the Institute of Astronomical and Geophysical Research and King Abdulaziz City for Science & Technology, the official Saudi authority for the calendar, accessed online at http://www.icoproject.org/sau.html on 2 April 2008

The Jewish calendar is based on three astronomical phenomena: the rotation of the Earth about its axis (a day); the revolution of the moon about the Earth (a month); and the revolution of the Earth about the sun (a year). These three phenomena are independent of each other, so there is no direct correlation between them. On average, the moon revolves around the Earth in about 29½ days. The Earth revolves around the sun in about 365¼ days, that is, about 12.4 lunar months.

The Gregorian calendar used by most of the world has abandoned any correlation between the moon cycles and the month, arbitrarily setting the length of months to 28, 30 or 31 days.

The Jewish calendar, however, coordinates all three of these astronomical phenomena. Months are either 29 or 30 days, corresponding to the 29½-day lunar cycle. Years are either 12 or 13 months, corresponding to the 12.4 month solar cycle.[41]

There is a lunar element in the current Western calendar, with the dating of Easter, which like the Jewish calendar is lunisolar. The definition of Easter is supposedly the Sunday after the first Full Moon on or after the day of the vernal equinox, but western and eastern churches interpret this differently (the eastern church uses the real Full Moon at the longitude of Jerusalem to determine the day, while the western church uses a calculation which is effectively based on a virtual Moon based on a 19-year cycle).[42]

[40] Dates calculated from http://prayer.al-islam.com/convert.asp?l=eng accessed 3 April 2008
[41] Details from the "Judaism 101" website at http://www.jewfaq.org/calendar.htm, accessed 2 April 2008
[42] See http://www.liturgies.net/Easter/TheDateOfEaster.htm for details, accessed 2 April 2008

The time from one new Moon to another is about 29½ days, and the word "month" derives from "moon".[43] The new Moon has a technical definition defined as the point when 'the Moon has the same celestial longitude as the Sun', but this is not visible, which is why the Islamic calendar was based until very recently on the first visibility of the crescent Moon.[44] This definition was also used in early Babylonian times according to van der Waerden: 'The month always began in the evening with the first sighting of the lunar crescent. Therefore the months had 29 or 30 days in irregular succession'.[45]

In a lunar calendar, if the first sighting of the crescent is counted as day 1 of a month, then the next crescent Moon will either be seen on day 30 (which then becomes day 1 of the following month so the preceding month had 29 days), or day 31 (which becomes day 1 of the following month so the preceding month had 30 days).

There are not an exact number of lunar cycles in a solar year; as described in the definition of the Jewish calendar, there are about 12.4 lunar months in a year. The three examples already given – the current Western solar calendar, the Islamic lunar calendar, and the lunisolar Jewish calendar – are the three basic calendar methods. The Babylonian system, like the current Jewish calendar, was lunisolar and made use of an "intercalary" month to bring the lunar calendar back into line with the solar seasons periodically. This thirteenth month was added after the sixth month (Ululu) or the twelfth month (Addaru).[46] This is a convention still

[43] *Oxford English Dictionary* (Oxford: OUP, 2008) [hereafter *OED*] online edition accessed on 2 April 2008 at http://dictionary.oed.com/cgi/entry/00315239
[44] Ridpath, *Dictionary of Astronomy*, entry for "new moon" accessed online 2 April 2008 http://www.oxfordreference.com/views/ENTRY.html?subview=Main&entry= t80.e2543
[45] van der Waerden, B, *Science Awakening II, The Birth of Astronomy* (Leyden: Noordhof, 1974) [hereafter van der Waerden, *Science Awakening II*], p.47
[46] Hunger & Pingree, *MUL.APIN*, p.153

adopted in the Jewish calendar today where the intercalary month is always added, when necessary, to the twelfth month (Adar in modern Hebrew).[47]

The lunar cycle is easy to measure, as the start of it simply involves watching for a crescent Moon after sunset. The main points of the solar year are not quite so trivial to measure, but can be done with fairly simple technology. The main four points of the year are the two equinoxes, when the time between sunset and sunrise is equal to the time between sunrise and sunset; and the two solstices, the summer solstice being the longest day and the winter solstice being the shortest day. At the equinox, the Sun sets due west and rises due east.[48] As the days shorten towards winter, the Sun rises and sets more and more in a southerly direction, ultimately rising towards the south east and setting towards the south west. By observing the Sun setting behind a hill each evening, this daily difference is obvious until the solstice, when the setting point appears to be the same on three consecutive evenings. The Sun appears to be standing still rather than doing its daily motion along the horizon, hence the name "solstice", meaning 'Sun standing still'.[49] Measuring the equinox is a little more involved – the point where the Sun sets due west is one rough and ready measure (and determining where due west is without a compass is not difficult, since the Sun culminates due south every day, which is easy to measure by observing when a shadow is at its shortest and in what direction that shortest shadow points). Neugebauer explains why this was significant:

> The driving force in the development of Babylonian astronomy was calendaric problems… So far as the solar year is concerned, we know that no serious attempt was made in earlier periods to establish fixed relations between the solar and the lunar

[47] http://www.jewfaq.org/calendar.htm#Months, accessed 2 April 2008
[48] Meeus, Jean, *Astronomical Algorithms*, 2nd ed. (Richmond, VA: Willmann-Bell, 1998) [hereafter Meeus, *Astronomical Algorithms*], p.404
[49] *OED* http://dictionary.oed.com/cgi/entry/50230491 accessed 2 April 2008

year; the intercalation of a 13th month was simply regulated according to the actual agricultural conditions of each individual year. For formal purposes, however, there existed a schematic calendar which assumed a year of 12 months of 30 days each. In order to characterize the solar year within this scheme, four points were selected: the equinoxes and the solstices.[50]

Another is to attempt to measure the length of day and night. The Babylonians did this using water clocks, where water was poured into a vessel with a small hole in the bottom, and used as a timepiece.[51] When the daytime and night time periods were the same, it was the equinox. The technical evidence for Babylonian water clocks is given in full in the same paper from which the above quote comes, and is derived from passages in MUL.APIN, referring to 'mana', which appears to be a unit of weight of water in the clock; for example:

> ina Du'uzi ud 15 Sukudu Nirah u Urgulu innammaruma 4 mana massarti umi 2 mana massarti musi (on the 15th of Du'uzu the Arrow, the Snake and the Lion become visible; 4 minas is a daytime watch, 2 minas is a night time watch).[52]

The start of the new year is fairly arbitrary, but many cultures used the spring equinox as the start of the new year. The Babylonians did, the Iranians still do: 'No Ruz, new day or New Year as the Iranians call it, is a celebration of spring Equinox' according to the Iranian Cultural and Information Center website.[53] In Britain, "Lady's Day" (March 25), very close to

[50] Neugebauer, O., "Studies in Ancient Astronomy. VIII. The Water Clock in Babylonian Astronomy", *Isis*, Vol. 37, No. 1/2. (May, 1947), [hereafter Neugebauer, "Water Clock"] pp. 37-43
[51] Neugebauer, "Water Clock", p.39
[52] Hunger & Pingree, *MUL.APIN* p.41
[53] http://www.persia.org/Culture/nowruz.html accessed 2 April 2008

the spring equinox, was used as the start of the new year until calendar reform in 1752 changed this to 1 January.[54]

[54] Duncan, *Calendar*, p.311

The zodiac and constellations

The development of the calendar allowed diaries to be kept recording when a particular observation took place. To define where in the heavens an observation occurred, a convention is needed to describe celestial location, and the zodiac is one method of achieving this.

The word "zodiac" is in common usage. Many newspapers carry daily or weekly horoscope columns that refer to "signs of the zodiac", or mention the word assuming that their readers understand the term; for example, the *Daily Telegraph*, in an article attacking astrology, referred to astrologer Jonathan Cainer as the *Daily Mail*'s 'expert on the zodiac'.[55] Mystic Meg, the astrologer for *The Sun* newspaper in her daily horoscope column for 31 March 2008 starts off her forecast for those born under the sign of Libra: 'You will become the zodiac's expert in relationships now you have the sun and shrewd Mercury in place to help you deal with people skilfully'.[56]

The dictionary definition of "zodiac" is quite technical – the *Dictionary of Astronomy* gives the first two sentences of the definition as:

> The strip of sky up to 8° either side of the ecliptic against which the Sun, Moon, and major planets appear to move. The strip is divided into twelve signs of the zodiac, each 30° long.[57]

[55] *Daily Telegraph*, "Astrologers fail to predict proof they are wrong", 17 August 2003 accessed online at http://www.telegraph.co.uk/news/main.jhtml?xml=/news/2003/08/17/nstars17.xml on 2 April 2008
[56] Mystic Meg, *The Sun*, 31 March 2008, p.37
[57] Ridpath, *Dictionary of Astronomy*, entry for "zodiac" accessed online 2 April 2008 http://www.oxfordreference.com/views/ENTRY.html?subview=Main&entry= t80.e4074

It may therefore seem surprising that the term is common enough to be used in a tabloid newspaper without explanation. However, there is a good reason for this. A model of the solar system would show planets orbiting the Sun in regular cycles; the Earth takes one year to orbit the sun, the planet Mercury takes 88 days, Jupiter takes around 12 years.[58] Calculating the position of a planet in the sky relative to Earth was not trivial in the days before computer software became available, since planets move in elliptical, not circular orbits, and the fact that the Earth is also moving at the same time makes the geometry complex; even a simplified version of the calculations to do this takes up many pages of a textbook.[59] The more detailed calculations used by NASA's Jet Propulsion Laboratory (these are publicly available and used widely in contemporary astronomy and astrology computer programs, such as the "Swiss Ephemeris") are so complex that an entire book is required simply to explain how to use the data.[60] Historically, calculating the position of planets has been complex and not always accurate and most sky watchers from the time of Ptolemy onwards have made use of "ephemerides", tables of positions of the planets.[61] These are still widely used by astrologers today.[62] However, the one celestial body whose position (at least approximately) is very easy to calculate is the Sun. Since the Earth takes one year to orbit the Sun, on any given date (provided a solar calendar is used) the Earth is in roughly the same relationship to the Sun as it was on the same date in previous years. From our perspective on Earth, the Sun appears to be moving in the sky against the backdrop of stars; the path the Sun takes through the year is called the "ecliptic", and this is of particular significance for locating planets because all planets lie roughly in the path of the ecliptic as can be seen from the definition of the zodiac

[58] Rükl, Antonín, *A Guide to the Stars, Constellations and Planets* (London: Caxton, 1998), [hereafter Rükl, *Guide to Stars*] p.221
[59] See for example Duffett-Smith, Peter, *Easy PC Astronomy* (Cambridge: Cambridge University Press, 1997) [hereafter Duffett-Smith, *Easy PC Astronomy*] pp.63-75
[60] Treindl, Alois, *Swiss Ephemeris* software available at http://www.astro.com/swisseph. Heafner, Paul J, *Fundamental Ephemeris Computations for use with JPL data* (Richmond, VA: Willmann-Bell, 1999) [hereafter Heafner, *JPL data*]
[61] See Neugebauer, *HAMA* for the various mathematical methods employed

given above.[63] This means that it is possible to locate a planet reasonably well by giving just one co-ordinate, namely how far along the ecliptic the planet is to be found. An observer may need to look up or down a little from the ecliptic, but since none of the planets known to the ancients stray more than 8º from it, from a visual observational view, the single co-ordinate is sufficient.

As described in the definition of the term "zodiac", the ecliptic is divided into twelve equal 30º segments called zodiac signs, and at any given date in the year the Sun will appear to be at roughly the same point on the ecliptic as it was the previous year. This means that on 15 March the Sun will be about 80% of the way through the zodiac sign called Pisces regardless of whether the year is 2002 or 2070.[64] As astrology is based on knowing where all the planets were at the moment somebody was born, anyone born on 15 March will have their Sun in Pisces.[65] The position of the other celestial bodies, such as the Moon or Jupiter, will differ according to their year of birth – and since publishing a list of planetary positions for every possible date of birth would take up a lot of space (around 600 pages in the case of *The New American Ephemeris*), it is easy to see why most people tend to know their "Sun sign"; for example, a survey involving 46 humanities students at the University of the West of England found that all of them knew their Sun sign.[66] Discovering that initially may simply have involved looking up their date, but not year, of birth in a brief twelve-paragraph newspaper horoscope.

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[62] See for example, Pottenger, Rique, *The New American Ephemeris for the 21st Century* (Exeter, NH: Starcrafts, 2006) [hereafter Pottenger, *American Ephemeris*]
[63] Ridpath, *Dictionary of Astronomy*, entry for "ecliptic" accessed online 2 April 2008 http://www.oxfordreference.com/views/ENTRY.html?subview=Main&entry= t80.e1089
[64] As an example, according to Pottenger, *American Ephemeris*, 15 March 2002 Sun was at approx. 24º13'Pisces, 15 March 2070 it will be at 24º45' Pisces
[65] As can be seen from the examples given in the previous footnote
[66] Blackmore and Seebold, "The Effect of Horoscopes on Women's Relationships", *Correlation* 19 (2) 2001 p.19

The *Oxford English Dictionary* defines the etymology of the word "astrology" as 'telling of the stars,' or 'one who tells of the stars, an astronomer,' from the Greek terms αστερον ("asteron", star) and λογος ("logos", speaking), although modern astrology is more concerned with planets than stars.[67]

The confusion arises because, as the late Vivian Robson, an astrologer who specialised in work on stars in astrology explains:

> in the early days of astronomy the celestial bodies or stars were divided into two groups, the one consisting of the fixed stars and the other of the "erratic" or wandering stars which we now call planets.[68]

Ptolemy uses the terms interchangeably; for example, in *Tetrabiblos* I.19 he uses the word πλανωμενων ("planomenon") to mean 'planetary' in the chapter referring to planetary exaltations: 'Τα δε καλοθμενα των πλανωμενων υψωματα λογον εχει τοιονδε'.[69] The English translation for this is given as 'The so-called exaltations of the planets have the following explanation'.[70] However, in *Tetrabiblos* I.6, the chapter headed in the English translation 'Of Masculine and Feminine Planets' is, in the Greek, headed 'Περι αρρενικων και θηλυκων αστερων' where the word αστερων ("asteron") is used for 'planets'.[71] In the same chapter the English translation mentions the planets by name but goes on to say 'They say too that the

[67] OED, http://dictionary.oed.com/cgi/entry/50013821 accessed 4 April 2008. Two modern astrologers describe modern astrology as being concerned with planets rather than stars in Parker, Derek and Julia, *The New Compleat Astrologer* (London: Mitchell Beazley, 1984) [hereafter Parker, *Compleat Astrologer*] p.64
[68] Robson, Vivian, *The Fixed Stars and Constellations in Astrology* (Bournemouth: Astrology Classics, 2004) p.11
[69] Ptolemy, *Tetrabiblos* I.19 "Of Exaltations", p.88
[70] Ptolemy, *Tetrabiblos* I.19 "Of Exaltations", p.89
[71] Ptolemy, *Tetrabiblos* I.6 "Of Masculine and Feminine Planets", p.41

stars become…' instead of 'planet', although the Greek term is from the same root, αστερας ("asteras").[72]

Astrology, then, is concerned with celestial bodies in our solar system – the planets, the Sun and the Moon. When somebody looks up their "Sun sign" in a newspaper horoscope column, they are reading a forecast based on which portion of the sky the Sun was in when they were born. A more detailed astrological forecast will involve looking at other bodies besides the Sun – the Moon and the planets, and which "zodiacal sign" they are in.

In the same way that any location on the surface of the earth can be defined by giving its latitude and longitude, the position of any body in the sky can be defined by giving two co-ordinates: how high up or low down to look, and how far round to turn one's head left or right. There are three common ways of doing this.[73] One is to measure the position of the body by giving a direction (for example, north-east) and to measure the upwards angle needed to see the body, where 0º is looking straight ahead and 90º would be looking directly overhead. This system is very simple to measure, but is very limited in use as it would vary according to where on the earth the observer was standing. In this co-ordinate system, called the "horizon system", the direction is called the azimuth and is usually given in degrees from an agreed starting point, for example the number of degrees clockwise from due north, and the number of degrees upwards is called the altitude.[74] For more general use, that does not depend on the observer being at a specific location on the Earth, astronomers use a co-ordinate system based on the celestial equator. The celestial equator is the projection of the Earth's equator projected outwards onto the sky so that it would correspond to the horizon if one were standing on the north pole, and would bisect the sky directly overhead if one were

[72] Ptolemy, *Tetrabiblos* I.6 "Of Masculine and Feminine Planets", p.41
[73] Meeus, *Astronomical Algorithms*, pp91-96

standing on the equator. Astronomers call the elevation above or below the celestial equator 'declination' and the distance around the celestial equator is called 'right ascension'.[75]

Astrologers since the time of Ptolemy, however, generally use a co-ordinate system based on the ecliptic, (already defined in the first section).[76] The ecliptic is inclined to the celestial equator at an angle of about 23º equivalent to the Earth's tilt.[77] Since, as has been seen, planets don't stray more than 8º from the ecliptic, most astrological charts ignore the "up-down" element of the position, collapsing the two dimensional co-ordinate onto a single line, the ecliptic:

> [The Greeks] applied reductionist thinking to the sky and in their pursuit of logic they gave us the ecliptic… and then, by measuring all other celestial objects against their newly made ruler, the astronomers/astrologers placed the rest of the visible universe within the sun's domain. This reductionism of the sky removed its spherical dimensions, removed the "roundness" and replaced it with a single line. This removed from the astrologer's process the need to observe or look at the sky. Any object in the visible universe which was to be placed onto the astrologer's maps was now only considered as a point located on the new sun-sky ruler.[78]

Whether using right ascension or ecliptic co-ordinates, when stating "how far around" the celestial equator or the ecliptic a planet lies, a starting point is required – and by convention, both Western astrologers and astronomers use the position of the Sun on the day of the vernal

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74 Heafner, *JPL data*, pp.49-50
75 Heafner, *JPL data*, p.50
76 Ptolemy, *Tetrabiblos* I.9 p.47
77 Heafner, *JPL data*, p.25
78 Brady, Bernadette, "Fixed Stars, why bother?" article on *Skyscript*, astrology website, at http://www.skyscript.co.uk/bb1.html accessed 11 April 2008. For an example of a chart displaying ecliptic

equinox as the starting point. This is an astronomical point, called the "vernal equinox" or the "first point of Aries", has the symbol ♈ and represents the intersection of the ecliptic and the celestial equator.[79]

Although it is perfectly possible to state the position of a planet as being a given number of degrees from this starting point, the convention in astrology is to divide the ecliptic into twelve equal "zodiac signs" of thirty degrees, each with its own name, and to state how far into a particular sign a planet is. Thus if Mars is 67 degrees from the vernal equinox point along the ecliptic, an astrologer would say it is at "7 degrees of Gemini", since the segment of the ecliptic from 0º to 30º from the vernal equinox is the first "zodiac sign", conventionally called Aries, the next segment from 30º to 60º is the second sign, Taurus, and the segment from 60º to 90º is the third sign, Gemini.[80]

The question of whether a planet is above or below the ecliptic, and by how far, is generally ignored in astrology, although some astrologers do make use of declination (which, rather confusingly, uses the celestial equator as its reference point, as has been explained above), as this introduction to an astrological "special interest group" on declination shows:

> In some Ephemerides you can still find declination together with longitude… But many Ephemerides don't give them anymore. And so many astrologers forgot one of the two dimensions of real astrology. It's like giving one an address with only the street name without house number.[81]

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longitude only see chart of Johnny Depp in Cunningham, D., "The Vocational Picture", *The Mountain Astrologer* Apr/May 2008 Issue #138, p.11

[79] Duffett-Smith, *Easy PC Astronomy*, p.38

[80] See for example, Parker, *Compleat Astrologer*, table of absolute longitude p.180

[81] *Declination*, an article on the Mandala website at http://www.mandala.be/declination/why.htm accessed 11 April 2008

The definition of the zodiac given above makes no mention of constellations, the patterns that stars make in the sky. MUL.APIN, the Babylonian text detailing the rising times of stars, refers to patterns of stars in the sky rather than zodiac signs by name, many of which correspond to the zodiac signs in Hellenistic astrology.[82]

One particular assumption that runs through much of the existing literature is that the constellations defined by the Babylonians, being visual, are unequal in size. Swerdlow, for example, states:

> The zodiac, its twelve equal signs, and the divisions of signs into uš and its fractions are purely conventional, an abstraction intended to facilitate computation, as in the ephemerides, while retaining the names of constellations of stars of irregular lengths unsuitable for computation.[83]

The stars used to define the boundaries of modern zodiacal constellations today correspond reasonably closely to those defined in Ptolemy's *Almagest*, and are indeed of irregular length. For example, the boundary stars for Pisces go from 'the star on the knot joining the two fishing-lines' at 2°30' of the zodiac sign of Aries, the star nowadays called Al-Rescha or alpha Piscium, to 'the star in the mouth of the advance fish', relating to the star we call beta Piscium at 21°40' of the zodiac sign of Aquarius.[84] Although the modern boundary is slightly wider (it includes the star 2 Piscium, which wasn't known to Ptolemy), it is a reasonably close fit and spans more than forty degrees of the ecliptic.[85]

[82] This is discussed later in this dissertation, and see also Hunger & Pingree, *MUL.APIN*
[83] Swerdlow, N. M., *The Babylonian Theory of the Planets* (Princeton, NJ: Princeton University Press: 1998), [hereafter Swerdlow, *Babylonian Theory of the Planets*] p.34
[84] Ptolemy, *Almagest*, pp.379-380

Although the names of many zodiac constellations in Greek corresponded to constellations of the same name in Mesopotamian astronomy, not all did, as shall be seen. The question of whether the Babylonian constellations are as dramatically unequal in size as the ones defined in Ptolemy's *Almagest* will be investigated in more detail.

[85] Rükl, *Guide to Stars*, p.127

Problems encountered

There is a controversy in terms of dating many of the Babylonian texts in, for example, the dates of observations recorded in the text known as MUL.APIN, which records the rising and setting details of stars. While Pingree maintains it was compiled in around 1000 BCE, or at least referred to observations made in or around that date, van der Waerden and Papke conclude that the date is around 2300 BCE, based on the dates that particular stars were said to rise with the Sun.[86] Identifying the stars referred to in the literature and ascertaining the intended boundaries of constellations is critical in being able to do any analytical work in this field, including dating the texts. When a text refers to the first star in a constellation rising, it is important to know which star is being referred to, and the current literature does not address fully the issue of where the boundaries of constellations lie.[87] There is a lack of raw material for undertaking detailed research, since many cuneiform texts have not yet been transcribed let alone translated.[88] Many early Greek texts referred to by later Hellenistic authors such as Hipparchus's star catalogue have never been found so there is a gap in academic knowledge.

There are also problems in correlating observations in the Babylonian texts such as MUL.APIN with actual calendar dates, since the former uses an "ideal" calendar, which does not correspond to a real calendar. MUL.APIN gives details of rising dates of various stars, and of stars culminating as other rise. However, it is not possible to correlate a date in MUL.APIN to a precise calendar date – a date of 15 Nisannu is by definition a full Moon in the month around the spring equinox, for example, as shall be seen, but fifteen days after the spring equinox is not always a full Moon, so the actual date each year will vary. Similarly, the

[86] Hunger & Pingree, *MUL.APIN*, pp.10-11

level of accuracy intended by the Babylonians when they said a star was culminating is not known, for example whether it was supposed to be almost exactly due south, or simply “roughly” south. It is not known whether the elevation of the culminating star was considered more important than its azimuth. These considerations impact on the accuracy of attempting to date observations or define clear boundaries, and are examined in detail in the ‘Methodology’ section of this dissertation.

[87] See for example, Hunger, H and Pingree, D, *Astral Sciences in Mesopotamia* (Leiden: Brill, 1999) [hereafter Hunger & Pingree, *Astral Sciences*] p.54
[88] Campion, *Apocalypse*, p.14

Early indications of a zodiac

In Babylonia

It is known that the Mesopotamians, who were interested in celestial omens such as eclipses and the appearance of the planet Venus, had devised a system for locating planetary positions by reference to the fixed stars by about 1800 BCE.[89] "Omen literature" dating back to what Hunger and Pingree refer to as the 'Old Babylonian' period of the second millennium BCE also shows that the ancient Mesopotamians were aware of planets and stars.[90] However, these earliest texts only demonstrate an appreciation of planets and stars, and do not in themselves constitute evidence for the existence of a zodiac at that time. Rochberg describes that tradition as going back to the second millennium BCE, but consisting 'not of astronomy but of celestial divination'.[91] Since this dissertation is considering the development of the zodiac, the period that will be investigated does not go back earlier than what Rochberg calls the 'Middle Assyrian period' from 1350-1000 BCE.[92]

As will be demonstrated, dating texts from Babylonian sources is difficult and in many cases still speculative. A 59-page booklet published in 1912 by the British Museum describes the discovery of forty nine clay tablets containing cuneiform texts, and describes one text that will be explored in detail in this dissertation:

> The most important text given herein is a Neo-Babylonian copy of an astronomical treatise made in the fifth century before Christ. It contains classified lists of the

[89] Hunger & Pingree, *MUL.APIN*, p.11
[90] Hunger & Pingree, *Astral Sciences* p.7
[91] Rochberg, *Heavenly Writing*, p. xi

> principal constellations and fixed stars known to the Babylonians, the times of their heliacal risings and settings, the times of their culminations in the south, etc.
>
> This text throws very important light upon the history of the study of astronomy among the Babylonians, and furnishes data for the identification of the principal fixed stars and constellations known to them. It suggests, moreover, that in the fifth century before Christ no mathematically accurate system of astronomical observations had been evolved.[93]

The text referred to is described as follows:

> This text… is one of the most important astronomical inscriptions that has yet been recovered… The text forms the First Tablet of an astronomical treatise, termed *(kakkabu) Apin* from the opening words of the composition. It is inscribed in a minute hand on a small clay tablet, measuring 2⅜ in. in width, $3\frac{5}{16}$ in. in height, and ¾ in. in thickness; and, although the closing lines of the colophon, which probably contained the date, are wanting, the forms of the characters suggest that it may be assigned to a period of about 500 B.C.[94]

This text is now usually referred to as MUL.APIN since the convention among Assyriologists now is that when the cuneiform depicts an older Sumerian logogram to represent an Assyrian or Akkadian word, the Sumerian word is used, in a capitalised form, in the Romanised

[92] Rochberg, *Heavenly Writing*, p. xxiii
[93] British Museum, *Cuneiform Texts from Babylonian Tablets, &c., in the British Museum, Part XXXIII*, transcribed by King, L. W. (London: British Museum, 1912) [hereafter British Museum, *Cuneiform Texts*], third page
[94] British Museum, *Cuneiform Texts* fourth page.

spelling.[95] The logogram used in the cuneiform is the word "MUL" in Sumerian, which means "star".[96] This same logogram is called "kakkabu" in Assyrian, hence the reason that the 1912 literature refers to it as '(kakkabu) Apin'.[97]

The 1912 paper refers to 'this text' as a single object, although MUL.APIN is derived from a collection of cuneiform tablets, many discovered after the original 1912 paper was published, one of which contained a date, equivalent to 687 BCE.[98] As Hunger and Pingree point out:

> This does not help us to fix a date for the actual time of compilation of MUL.APIN, however, because the source material may have been available for a long time without having been collected and arranged in what was then called MUL.APIN.[99]

Van der Waerden uses an astronomical argument – the list of dates of first visibility in MUL.APIN – to conclude that 'the best fit is obtained if the calculation is made for Babylon between 1300 to 1000 B.C.', a date with which Hunger and Pingree agree although they disagree with the location of Babylon used by van der Waerden, considering that the texts 'point to Assyria as the place'.[100] Other estimates place MUL.APIN even further back in the past, to 2300 BCE, based on the assumption that the first star in the constellation referred to as 'the arrow' is in fact the star Procyon, which could not have risen on the specified date in the accepted date range of 1300 to 1000 BCE, but could only have done so a thousand years

[95] Caplice, Richard, *Introduction to Akkadian* (Rome: Biblical Institute Press, 1988) [hereafter Caplice, *Akkadian*] p.6
[96] Halloran, John, *Sumerian Lexicon v 3.0*, p.32 accessed online at http://www.sumerian.org/sumerian.pdf on 8 April 2008
[97] Lyon, D.G., *Beginner's Assyrian* (New York: Hippocrene, 1998) [hereafter Lyon, *Beginner's Assyrian*] p.xx logogram 65
[98] Hunger & Pingree, *MUL.APIN* p.9
[99] Hunger & Pingree, *MUL.APIN* p.9
[100] van der Waerden, *Science Awakening II* p.75; Hunger & Pingree, *MUL.APIN* p.10

earlier – a thesis first proposed by Papke, but supported by van der Waerden later on.[101] The MUL.APIN text is thus dated as being in the fifth century BCE according to the British Museum document when it was published in 1912, 1000 BCE by Hunger and Pingree, and 2300 BCE by other authors including van der Waerden.

Another of the objects identified in the 1912 paper comprised 'five portions of clay planispheres', one of which is circular and divided into eight segments, but 'the remaining planispheres give lists of the thirty-six stars associated with the twelve months of the year'.[102] The fragments of these objects were studied by Pinches, who combined them to reconstruct a single 'astrolabe', generally referred to as 'Astrolabe P' as described by van der Waerden:[103]

> The first and most important astrolabe is not a cuneiform text, but a modern compilation made by Pinches from different texts in the British Museum. Most of these texts are now lost… Pinches' transcription (P) is so accurate that there is in no case any doubt as to which cuneiform sign he read. Hence this transcription can be treated as if it were a cuneiform text. In this Astrolabe P, the stars were arranged in three concentric rings.[104]

Dating the astrolabes presents the same problems as dating MUL.APIN. The latter is more detailed than the astrolabe, since it not only gives the thirty-six stars associated with the twelve months, as does the astrolabe, but gives rising dates, additional details about 'constellations in the path of the Moon' and 'ziqpu' (culminating) stars.[105] For this reason,

[101] Hunger & Pingree, *MUL.APIN* p.11
[102] British Museum, *Cuneiform Texts* third page, and plates 10-12
[103] Pinches, T, *Journal of the Royal Asiatic Society* (London: Royal Asiatic Society, 1900) p.573
[104] van der Waerden, "36 Stars", p.10
[105] Hunger & Pingree, *MUL.APIN*, p.13

van der Waerden postulates that the astrolabes pre-dated MUL.APIN and dates the earliest surviving astrolabe text to 1100 BCE.[106]

The visual similarity of Pinches' astrolabe to a zodiac circle is noticeable, in the sense that it is circular, it is divided into twelve equal segments, and the names of many of the constellations on them are the Babylonian names for constellations that are now considered zodiac constellations, so that 'MUSH.TAB.BA.GAL.GAL' means 'The Great Twins', and equates to the constellation of Gemini.[107] However, the astrolabes show not twelve constellations, but thirty-six, in accordance with the Babylonian Creation Epic where it is written 'He (Marduk) made the year, divided its boundaries, (For the) 12 months three stars each he set'.[108] In the astrolabes, each one-twelfth segment of the astrolabe shows three stars, arranged in three paths named after three gods, Anu, Ea and Enlil. These paths roughly correspond to declination, the innermost circle being the Path of Enlil including circumpolar stars, the outermost Path of Ea containing those of a southerly declination, and the middle Path of Anu being between these two, and this is spelled out fully in MUL.APIN giving lists of stars in each of the paths.[109] MUL.APIN starts by listing 33 stars in the path of Enlil: 'The Plow, Enlil, who goes at the front of the stars of Enlil' and enumerates them all.[110]

Although the astrolabes are useful source material because their obvious division of a circle into twelve equal parts is suggestive of a zodiac, researching this question more deeply requires more detail. In particular, the fact that the Babylonians had a constellation called 'The Great Twins' does not in itself prove that that constellation corresponds exactly to the classical Greek constellation of Gemini. More detailed evidence is required, and from this

[106] van der Waerden, *Science Awakening II* p.65
[107] van der Waerden, *Science Awakening II* p.73
[108] van der Waerden, *Science Awakening II* p.64
[109] van der Waerden, *Science Awakening II* p.66

perspective MUL.APIN is extremely useful because it is much more sophisticated than the astrolabes. MUL.APIN lists stars in the three paths, heliacal rising dates, meridian stars, constellations that stood ‘in the path of the Moon’, the number of days between stars rising, and which constellations and stars were rising while others were setting. The fact that MUL.APIN gives dates for stars rising, and uses a notation that says when a star at the ‘start’ of a constellation becomes visible, means that MUL.APIN can be used to define constellation boundaries, at least tentatively.

For example, MUL.APIN has sentences such as these: ‘On the 20th of Nisannu the Crook becomes visible’ and ‘On the 1st of Ajjaru the Stars become visible’.[111] ‘The Crook’ refers to a constellation; much of the research that I have undertaken for this dissertation has involved using software (primarily *Starlight*, *Stellarium* and *Solar Fire*) to calculate which stars rose on particular dates to help identify Babylonian constellations, in addition to seeing what other authors have to say on the matter.[112] In the examples just given, there is agreement that ‘MUL.GAM’, the word translated as ‘the Crook’, refers to at least part of the constellation Auriga, with α Aurigae (the star Capella) being the first star in that constellation to rise, by Hunger and Pingree and van der Waerden[113]. Similarly, both authors agree that ‘MUL.MUL’, the word translated as ‘the Stars’, refers to the Pleiades (specifically η Tauri or Alcyone), a grouping small enough to be considered a point rather than a constellation.[114]

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110 Hunger & Pingree, *MUL.APIN*, p.18
111 Hunger & Pingree, *MUL.APIN*, p.40
112 *Starlight*, by Zyntara Publications, http://www.zyntara.com has been used for all calculations relating to rising and setting times of stars and planets in this dissertation. *Stellarium*, Open Source software available at http://www.stellarium.org, provides an accurate rendition of the night sky and has been used to confirm *Starlight* data and to check actual visibility of planets and stars. *Solar Fire*, astrology software available from http://www.alabe.com has been used to calculate dates of new Moons and planetary stations.
113 Hunger & Pingree, *Astral Sciences*, p.69; van der Waerden, *Science Awakening II*, p.76
114 Hunger & Pingree, *Astral Sciences*, p.71 and der Waerden, *Science Awakening II*, p.76

The argument for dividing the ecliptic into twelve, rather than any other number, is fairly clear. Texts dating from around 700 BCE measure arcs along the horizon in units called 'uš' and 'beru', with a circle being divided into 12 beru, or 360 uš.[115] The Mesopotamian calendar was a combination of solar and lunar – each month beginning when the crescent Moon was visible, resulting in a 29 or 30 day month (the time from one new Moon to the next being about 29½ days). Eclipse omens show that the "normal" day for a lunar eclipse was the fourteenth day of a lunar month, and that there was a great fear of astronomical phenomena occurring on the "wrong" day, such as a full Moon on the twelfth day of a month.[116] Intercalary months were needed to keep the seasons in step – the beginning of the year ideally fell at the new Moon nearest the vernal equinox. MUL.APIN gives dates in an 'ideal calendar' in which one month comprises thirty days, and one year is twelve months.[117]

The fifth tablet of the Enuma Elish, the creation myth, states: 'Marduk determined the year, defined the divisions; for each of the twelve months he set up three constellations'.[118] This frequent reference to the number twelve does not in itself comprise clear-cut proof of a direct connection between twelve months and twelve signs; the three constellations for each of the twelve months include circumpolar stars in addition to the zodiacal constellations.

It certainly seems to be the case that the astronomical records written by the Mesopotamians were far broader than the Hellenistic obsession with the zodiac; the 'three paths' of Ea, Anu and Enlil show that they looked at the whole sky and not just the single band of the ecliptic. However, the ecliptic can be considered a very useful band for determining the positions of planets, which never stray too far from it. The initial attempt to do this was based on

[115] Hunger & Pingree, *Astral Sciences*, p.41
[116] Hunger & Pingree, *Astral Sciences*, p.16
[117] Hunger & Pingree, *MUL.APIN*, p.10
[118] van der Waerden, "36 Stars", p.10

constellations that can appear in the path of the Moon, creating a wider band than just the ecliptic and taking in some constellations that are not considered to be zodiac constellations today.[119]

One comprehensive list of stars is to be found on the so-called ‘Gu’ text, inscribed between the seventh and fifth centuries BCE, listing stars in order of longitude and specifying the ‘ziqpu’ stars (stars visible on the meridian).[120] Significantly, this text also includes three planets – Jupiter in the Crab (Cancer), Mercury with the barley-stalk (Virgo), and Saturn in front of the Scales (Libra). Since these planets are of course not always in these signs, this would seem to be an early example of planets having “favoured places”, echoed as will be seen later in this section of this dissertation, with an example of Saturn in Libra in MUL.APIN, where these planets are shown in their “hypsomata”, or places of exaltation. The exaltation of Jupiter in Cancer, Mercury in Virgo and Saturn in Libra was used by the Greeks.[121] MUL.APIN works on a month by month basis, as do the astrolabes.

Since texts such as the MUL.APIN were written at a time when the Akkadians, who spoke a Semitic language, were ruling Babylonia, it may be instructive to look at one other Semitic source, the Bible, to see if there are any hints at a twelve-fold zodiac. This is highly speculative, but there is one book that has a lot of direct astronomical allusion, and this is the Book of Job. However, we must be careful about reading too much into translations, even modern and academically well-researched ones such as this verse in the New Revised Standard Edition of the Bible: ‘Can you bind the chains of the Pleiades, or loose the cords of

[119] Hunger & Pingree, *MUL.APIN*, p.67
[120] Hunger & Pingree, *Astral Sciences*, p.90
[121] Ptolemy, *Tetrabiblos* I.19, p.89

Orion? Can you lead forth the Mazzaroth in their season, or can you guide the bear with its children?'[122]

The original Hebrew is rather less specific about astronomical nomenclature. For instance, the word for Orion in the original is כסיל ("k'syl"), which literally means 'a fool' but with a suggestion of being large and burly, or fat, so that 'can you loose the cords of Orion' suggests he is seen as a burly giant bound to the sky.[123] So Similarly, 'mazzaroth' is defined as 'the twelve signs of the zodiac and their 36 associated constellations' according to Thayer's Lexicon.[124] However, the Brown, Driver, Briggs (BDB) Hebrew and English Lexicon defines this as 'constellations, perhaps signs of the zodiac' as a loan word from the Assyrian – giving 'manzaltu, mazaltu: station or abode of the gods.' The implication according to BDB is that in the book of Job alone it is used for a specific constellation, but which one, we don't know.[125] The date Job was written is not known for certain, but most scholars place it somewhere between 800 BCE and 300 BCE, and there are Sumerian versions of the Job legend dating back to 2000 BCE, so we have a roughly concurrent time frame for the Book of Job and the Babylonian star texts, suggesting another very tentative link between signs of the zodiac and this period.[126]

The zodiacal signs can be argued to derive their names from the constellations in them and van der Waerden gives two requirements for the signs: 'the signs must be of equal length, and they must enclose the constellations after which they are named'.[127] He uses as an example the star Spica, called AB.SIN by the Babylonians, and after which they named the sign that is

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[122] *Bible (New Revised Standard Version)* (London: Harper Collins, 1997), Job 38:31-32
[123] Brown, F., Driver, S., Briggs, C. *The Brown-Driver-Briggs Hebrew and English Lexicon* (Peabody, MA: Hendrickson, 1996) [hereafter BDB], p.492
[124] As quoted by the Blue Letter Bible, at http://www.blueletterbible.com, accessed 10 April 2008
[125] BDB, p.561
[126] Mitchell, Stephen, *The Book of Job* (New York: North Point Press, 1987) p.xxxi
[127] van der Waerden, *Science Awakening II*, p.126

now called Virgo. Spica is at the very end of Virgo – ‘a small backward displacement of the boundaries, and the star AB.SIN would no longer be in the constellation of AB.SIN’.[128]

There is an assumption underlying all these questions of boundaries that either a neat mathematical 30º equal sign zodiac is needed for mathematical purposes, or that a visual “zodiac” is used with a loss of a regular way to denote planetary positions since this would be based on constellations, which are unequal.[129] The literature nowhere suggests that perhaps the constellations themselves could be defined in such a way as to make a purely visual zodiac equal in size.

There are several hints about this that are left largely unaddressed. For example, van der Waerden argues that the Babylonians, at the time of writing MUL.APIN, knew that the Sun moved in an inclined circle since the text mentions that not only the Sun, but the Moon and other five planets move along the same path and that the circle the Sun moved through was divided into ‘four equal parts by the zones of Ea, Anu and Enlil, so that the sun remained just three months in each sector’.[130] These four equal parts are defined by the solstices and equinoxes, as stated in MUL.APIN, which were divided further into three solar months.[131] As van der Waerden points out, the circle at this stage was divided only into four parts and ‘to reach complete agreement each of the four parts of the zodiac had to be subdivided into three parts of equal length’ and he is of the opinion that ‘this subdivision, which gave rise to the signs of the zodiac, was not made until somewhat later, in the Neo-Babylonian or Persian period’.[132]

[128] van der Waerden, *Science Awakening II*, p.126
[129] van der Waerden, *Science Awakening II*, p.126, and Rochberg, “Babylonian Horoscopes”, p.2
[130] van der Waerden, *Science Awakening II*, p.83
[131] Hunger & Pingree, *MUL.APIN*, p.139
[132] van der Waerden, *Science Awakening II*, p.83

He goes on to ask:

> What was more natural than to divide each of the 4 parts of the circle into 3 sections such that the sun dwells just 1 month in every section? Thus, one would have 12 sections of the zodiacal circle corresponding to the 12 months of the solar year.[133]

The fact that there are three stars given for each month in the astrolabes, and the rising stars are given for each month in MUL.APIN, implies that the Babylonians were already dividing up the sky into equal portions, based on an ideal month.

Rochberg points out that 'no evidence in the astronomical or astrological literature suggests that degrees within zodiacal signs were ever observed, and it may well have been the only solution to the problem of knowing when a planet would enter the next sign of the zodiac'.[134] This echoes Neugebauer, who puzzles over the importance of the ephemerides and suggests that the 'astrologically important question of a planet's crossing from one zodiacal sign into the next provided the initial stimulus'.[135]

This begs the question that if degrees are not used, but the only interest at this stage is to identify the constellation that a planet is in, what does it mean to talk of 'crossing from one sign to the next'? It is clear that the constellations are not arbitrary, because the later zodiacal signs were named after the constellations they contained and there is an intriguing reference in MUL.APIN to 'Saturn, also called the Scales', for which Hunger and Pingree give this commentary:[136]

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133 van der Waerden, *Science Awakening II*, p.122
134 Rochberg, "Babylonian Horoscopes", p.2
135 Neugebauer, *HAMA*, p.412
136 van der Waerden, *Science Awakening II*, p.79

> Saturn is identified with Scales presumably because Libra is its ašar nisirti (υψωμα)... If this is so, the occurrence of an ašar nisirti in MUL.APIN would be the earliest attestation of this idea yet known.[137]

The 'ašar nisirti' Hunger and Pingree translate as υψωμα ("hypsoma"), and this is the same word that Ptolemy uses to describe a zodiacal sign where a planet is exalted (having a particular kind of astrological strength).[138] Ašar means place and nisirti means "treasure" or "something guarded".[139] Koch-Westenholz mentions 'The Babylonian *bit nisirti* or *ašar nisirti* equals the hypsoma of Hellenistic astrology, the particular zodiacal sign in which a particular planet was thought to obtain its greatest significance'.[140]

However, it has already been seen that zodiac signs apparently did not exist at the time that MUL.APIN was written, so presumably Saturn being significant in Libra referred to the constellation of Libra and not the as yet non-existent zodiacal sign of Libra. If this is the case, then Libra was more than a set of stars, it was a region of space in which Saturn had significance when it passed through it. For this to apply, it can be argued that this region of space must have had defined boundaries, although whether this region was demarked by a given set of stars is not clear from the literature.

Thus, assuming the dating given by Pingree and others of MUL.APIN to around 1000 BCE to be correct, there is very little evidence for a clearly defined zodiac at this time, although tantalising glimpses can be seen of a twelve-fold division using heliacal rising stars, and the

137 Hunger & Pingree, *MUL.APIN*, p.86 & 146
138 Ptolemy, *Tetrabiblos* I.19, p.89
139 Lyon, *Beginner's Assyrian* p.102 and p.121
140 Koch-Westenholz, *Mesopotamian Astrology*, p.134

idea of ašar nisirti having a particular significance. Indeed, van der Waerden describes the zodiac at this time as being ‘in the wind’.[141]

[141] van der Waerden, *Science Awakening II*, p.122

In Greece

Neugebauer's implication that Hellenistic astronomy was a development of Babylonian astronomy, quoted in the 'Review of previous literature', overlooks the fact that an earlier Greek astronomy had itself been developing for centuries by the time of Ptolemy. Goldstein suggests that there was a cosmological tradition in Greece stretching back to the eighth century BCE where stars were organised into constellations.[142] This can be seen in Hesiod's *Works and Days*, with its references to 'Orion and Sirius are come into mid-heaven, and rosy-fingered Dawn sees Arcturus' and where the emphasis is on producing a calendar or "parapegma" based on the rising and setting of stars, very similar in principle to those seen in Babylonian texts such as MUL.APIN.[143]

The description of Achilles' shield in Homer's *Iliad*, also dates back to the eighth century BCE, and describes constellations and the fact that the Wagon or Bear is circumpolar and so does not rise or set, suggesting an interest in naming parts of the night sky, even if this does not yet constitute a formal Greek astrology:

> He decorated the face of it with a number of designs, executed with consummate skill and representing, first of all, Earth, Sky and Sea, the indefatigable Sun, the Moon at the full, and all the Constellations with which the heavens are crowned, the Pleiads, the Hyads, the great Orion, and the Bear, nicknamed the Wain, the only constellation

[142] Goldstein, Bernard, "A New View of Early Greek Astronomy", *Isis* Vol 74 No. 3 (Sep 1983), [hereafter Goldstein, "Early Greek Astronomy"] p.331
[143] Hesiod, *Works and Days*, II.609 accessed online at http://www.sacred-texts.com/cla/hesiod/works.htm on 10 April 2008

> which never bathes in Ocean Stream, but always wheels round in the same place and looks across at Orion the Hunter with a wary eye.[144]

Looking at the stars and making patterns from them is nothing new, and it seems likely that human beings have been forming pictures from the series of stars visible in the night sky for thousands of years; Rappenglueck claims that an ivory tablet, dated to 32,500 years ago, shows an image of the constellation Orion, and that Orion is depicted as a hunter.[145] It might seem strange that, given the human ability to create meaningful patterns from a random selection of dots, that cultures separated by some 30,000 years would come up with the same interpretation of the set of dots we call "Orion", but this does not constitute proof of a continuous transmission of ideas from that period. As someone who has always had some difficulty in spotting the various animals supposedly represented in constellations, I was startled to find a few years ago when showing a group of eight-year olds the pattern of dots that make up the constellation Leo, that about half the group, without any prompting, instantly recognised the image of some sort of big cat.

Thus none of the quotes from the Greek literature of the eighth century BCE imply a concept of a zodiac in ancient Greece. Glimpses of a twelve-fold division were described in the previous section as being 'in the wind' a thousand years before Ptolemy, but there is no evidence that these have echoes in the Greek literature of that period, simply that the Greeks of that period had an interest in the night sky.

[144] Homer, *Iliad* (Trans. Rieu, E.V) 18 481-9 (London: Penguin Classics, 1988), p.349
[145] Whitehouse, D., "Ice age star map discovered" http://news.bbc.co.uk/1/hi/sci/tech/871930.stm accessed 11 April 2008

The development of the zodiac

In Babylonia

Since planets are "wandering" stars, to record their positions some kind of notation is needed and by the fifth century BCE the evidence for an early zodiac becomes much stronger. Diaries by this time are using a mixture of stars and what appear to be signs. For example, an entry from a diary from 455 BCE states that 'the evening rising of Venus took place "behind Praesepe"', which is a star.[146] However, according to van der Waerden, there is evidence by this time that the division of the ecliptic into twelve to give a zodiac had also taken place, since an entry for 446 BCE states that 'the evening setting of Venus to place "in the end of Pisces"… this must mean the zodiacal sign and not the constellation Pisces.'[147] In addition to the fixed stars, formed into constellations, the Babylonian texts demonstrate an understanding of planetary theory such as the ephemeris for Saturn dating to early in the second century BCE.[148]

Rochberg contends that 'only after the introduction of the zodiac, as twelve signs of 30º each, some time in the fifth century BCE, did changes occur in the classical celestial omen tradition'.[149] There is consensus on this date; Koch-Westenholz says 'from the 5th century onwards, if not earlier, the ecliptic was divided into twelve sections of 30º each, giving rise to the zodiac still in use today'.[150] Van der Waerden concludes that 'horoscopy originated in Babylon before -450 and was already known in Greece before -440'[151]. Campion associates

[146] van der Waerden, *Science Awakening II*, p.125
[147] van der Waerden, *Science Awakening II*, p.125
[148] Neugebauer, *HAMA*, p.380
[149] Rochberg, *Heavenly Writing*, p.129
[150] Koch-Westenholz, *Mesopotamian Astrology*, p.52
[151] van der Waerden, *Science Awakening II*, p.182

this with the Persian invasion of Babylon in 538 BCE after which ‘tremendous developments took place in astrology with the first use of zodiacal signs, rather than constellations, around 432 BC’.[152]

Given that there was a period when a mixture of zodiac signs and stars were used, as in the examples from the diaries above, a problem arises with defining the boundaries between constellations when these are used instead of zodiac signs. Swerdlow makes this plain when asking ‘It is by no means obvious, and in fact is very unlikely, that the observational texts, the Diaries, use signs of equal length – for how would one know where their limits lie?’[153] He goes on to ask whether the zodiacal signs used in the diaries were equal length, in which case defining the boundaries would be problematic, or whether they were loosely defined regions relating to constellations.[154]

Rochberg dates the appearance of ‘horoscopes’ to the fifth century, stating that ‘The appearance of horoscopes in Babylonia at the end of the fifth century B.C. marks the point when the situation of the heavens at the time of a birth came to be regarded as significant for the future of an individual’.[155] She warns against making assumptions that horoscopic astrology necessarily implies the existence of clearly defined zodiacal signs, stating:

> certain concepts regarding the spherical universe, the ecliptic, the zodiacal signs, planetary influences, and methods of relating astronomical elements to both physical and psychic elements of an individual, all associated with horoscopic astrology in

[152] Campion, Nicholas, *An Introduction to the History of Astrology* (London: Institute for the Study of Cycles in World Affairs, 1982), p.11
[153] Swerdlow, *Babylonian Theory of the Planets* p.34
[154] Swerdlow, *Babylonian Theory of the Planets* p.51
[155] Rochberg, “Babylonian Horoscopes”, p.x

> Greco-Roman antiquity, must not be assumed *a priori* to find counterparts in the Babylonian texts.[156]

Sachs gives a working definition of horoscopic astrology:

> we must distinguish sharply between non-horoscopic astrology and horoscopy, maintaining a narrow definition of *horoscopy* as the prediction of an individual's future on the basis of (at least) the positions of the planets, sun, and moon at the moment of his birth or conception.[157]

In this sense, Sachs says that 'Once we limit our attention to horoscopy, evidence for the history of this all-important branch of astrology before 200 B.C. is hard to find'.[158] He goes on to suggest that horoscopy was developed in Babylonia rather than Greece, saying 'I find it very tempting to set up the working hypothesis that the basic idea of horoscopic astrology was first propounded in Babylonia' and citing 'the existence of the zodiac' as one indicator.[159]

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[156] Rochberg, "Babylonian Horoscopes", p.1
[157] Sachs, A., "Babylonian Horoscopes", *Journal of Cuneiform Studies* Vol 6 1952 [hereafter Sachs, "Babylonian Horoscopes"] p.50
[158] Sachs, "Babylonian Horoscopes", p.50
[159] Sachs, "Babylonian Horoscopes", p.51

In Greece

In the 'Early indication of a zodiac' section, Goldstein suggested a cosmological tradition stretching back to the eighth century BCE. He places the next phase of Greek astronomy as starting with Eudoxus, whom he credits as 'the person largely responsible for turning astronomy into a mathematical science' by drawing on the views of the Pythagoreans and Plato's concepts of circular orbits imposing a moral order on the cosmos.[160]

There are no extant writings from Eudoxus, nor from the later (second century BCE) Hipparchus whom Ptolemy quotes extensively in *Almagest* and whom Ptolemy credits with the discovery of precession.[161] Hipparchus produced a catalogue of stars, which has not been preserved, and it has been widely assumed that Ptolemy simply used Hipparchus' catalogue, adding the relevant correction due to precession of 2º40' to all longitudes.[162] Ptolemy claimed to have made observations himself and modern scholarship supports this claim, not least because Ptolemy's catalogue contains significantly more stars than Hipparchus' catalogue.[163] Ptolemy makes reference to 'Hipparchus' celestial globe' a point that Toomer, the translator of the edition of the *Almagest* used in this dissertation, comments on when he says in a footnote: 'I interpret this [mention of the globe] to mean that Hipparchus published a description of the constellations to be drawn on a celestial globe… What relationship, if any, this had to Hipparchus' putative Catalogue is obscure.'[164] Toomer refers to the Hipparchus' catalogue being drawn 'on a celestial globe', and in 2005 Schaeffer claimed to have

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[160] Goldstein, *Early Greek Astronomy*, p.332

[161] See for example Ptolemy, *Almagest*, p.139 where Ptolemy quotes from Hipparchus' work *On the length of the year;* Ptolemy, *Almagest*, p.329

[162] Neugebauer, *HAMA*, p.280

[163] Ptolemy, *Almagest*, p.327; See for example, Riley, Mark, "Ptolemy's Use of His Predecessors' Data", *Transactions of the American Philological Association*, Vol. 125. (1995), [hereafter Riley, "Ptolemy's Predecessors' Data"], p.237; Neugebauer, *HAMA*, p.285

[164] Ptolemy, *Almagest,* p.327 Toomer's comments on footnote 48.

discovered Hipparchus' lost star catalogue on the Farnese globe on a statue in the National Archaeological Museum in Naples.[165] This discovery is hotly disputed, however.[166] As well as producing a catalogue of stars, Ptolemy credits Hipparchus with making 'a compilation of the planetary observations' although not with the development of any theoretical basis, since Ptolemy claims that Hipparchus 'did not even make a beginning in establishing theories for the five planets, not at least in his writings which have come down to us.'[167]

Most writings from this period are lost, and there are only fragments from later Greek writers quoting them, such the poem *Phaenomena* by the Greek writer Aratus commenting on Eudoxus.[168] Although Aratus' work is poetic, the astrological content is clear: 'Beneath the head of Helice are the Twins; beneath her waist is the Crab; beneath her hind feet the Lion brightly shines'.[169] There is also a commentary on Aratus' *Phaenomena* showing that Aratus quoted Eudoxus as in this example saying that behind the constellation of the Great Bear can be found the guardian of the bears: 'Bootes, sagt Eudoxus, Hinter dem Grossen Bären befindet sich der Bärenhüter'.[170] Another source of information that refers back to earlier writers is a book, also called *Phaenomena*.[171] This work, by Geminos, is later and is in the form of a textbook rather than a poem, and was 'probably written in conjunction with teaching'.[172]

[165] Schaefer, Bradley, "The epoch of the constellations on the Farnese Atlas and their origin in Hipparchus's lost catalogue", *Journal for the History of Astronomy* Vol 36 Part 2 (2005), pp.167-196
[166] See for example, Duke, Dennis, "Analysis of the Farnese Globe", *Journal for the History of Astronomy* Vol 37 Part 1 (2006), pp.87-100
[167] Ptolemy, *Almagest*, p.421
[168] van der Waerden, *Science Awakening II*, p.40; Aratus (Trans. Mair, A. W. Loeb Classical Library), *Callimachus, Hymns and Epigrams. Lycophron* (London: William Heinmann, 1921) [hereafter Aratus, *Phaenomena*]
[169]Aratus, *Phaenomena* p.147
[170] Aratus (trans. Mantius, C.), Ιππαρχου των Αρατου και Ευδοχου φαινομενων εχηγησεως – Βιβλια Τρια (Hipparchi in Arati et Eudoxi Phaenomena Commentariorum, Libri Tres), (Leipzig: Mantius, Carolus, 1895) [hereafter Aratus, Phaenomena] p.9
[171] Evans, J. and Berggren, J, *Geminos's Introduction to the Phenomena: A Translation and Study of a Hellenistic Survey of Astronomy* (Princeton, NJ: Princeton University Press, 2006) [hereafter Evans & Berggren, *Geminos*]
[172] Evans & Berggren, *Geminos*, p.2

The concept of dividing the ecliptic into twelve equal signs was well established by the time Ptolemy was codifying Hellenistic thought in his *Tetrabiblos* in the second century CE; much of *Tetrabiblos* is devoted to describing the method of division and the meanings of each sign.[173] Most, but not all, signs are named after animals, and so the collection of signs is called a "zodiac" from the Greek word ζωδιον ("zodion") meaning a sculpted figure of an animal.[174]

The zodiac is a convenient way of dividing up the ecliptic into twelve equal portions. Ptolemy also wrote about astronomy as well as astrology, and his book *Almagest* lists 1,027 stars in great detail, which he groups into 48 constellations.[175] There are constellations in the far south that Ptolemy did not include as they would not have been visible from the latitudes with which Ptolemy would have been familiar; it is believed that Ptolemy lived and worked in Alexandria.[176] Ptolemy's own work on cartography, *Geography*, makes it clear that he was aware that there were stars that, from his perspective as a northern hemisphere observer, 'never rise and therefore are always invisible'.[177]

Astronomically, a star is considered to be a "southern hemisphere" star if its declination is negative, that is, the star is below the celestial equator.[178] This does not mean that an observer in the northern hemisphere can never see southern hemisphere stars; an observer will be able to see all stars (at some point) whose declination corresponds to their own hemisphere, and all stars whose declination is in the other hemisphere but with a value less than the observer's co-latitude, defined by the formula: co-latitude = 90 - latitude[179]

[173] See for example Ptolemy, *Tetrabiblos* I.11 p.65
[174] *OED* http://dictionary.oed.com/cgi/entry/50291318 accessed 2 April 2008
[175] Ptolemy, *Almagest* pp.341-399
[176] Ptolemy, *Tetrabiblos*, p.ix Translator's introduction
[177] Ptolemy, *Ptolemy's Geography: An Annotated Translation of the Theoretical Chapters*, trans Berggren, J. L., (Princeton, NJ: Princeton University Press, 2000), p.8
[178] Heafner, *JPL data*, p.50
[179] Duffett-Smith, *Easy PC Astronomy*, p.33

In Ptolemy's case, it is assumed he was writing at a latitude of 36º north. This means Ptolemy would have been able to see all northern hemisphere stars, and any southern hemisphere stars whose declination is more northerly than 54º south. Thus the star Canopus, whose declination in the time of Ptolemy was -52º34' according to *Starlight* would have been visible. The stars of the constellation "Octans", however – one of 14 new constellations introduced in the 1750s by Nicolas Louis de Lacaille – would not have been visible to Ptolemy which *Starlight* shows as having a declination of -84º37' for the star beta Octans in Ptolemy's time.[180]

Ptolemy's star catalogue is therefore incomplete, but he documented the stars he could see in such detail that many of his constellation definitions were adopted into the canon of 88 constellations and their boundaries recognised by the International Astronomical Union in 1930.[181] Twelve of these constellations have the same names as the zodiac signs: Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricorn, Aquarius and Pisces. At the time that Ptolemy was writing, the Sun was among the stars of the constellation Aries at the vernal equinox, so the precise thirty degree segment of the ecliptic called "Gemini" overlaid the constellation of the same name – and this held true for all the zodiac constellations.[182] The overlay was not precise, since Ptolemy's constellations (and indeed modern constellations) do not all span exactly thirty degrees. The constellation of Pisces, for instance, whether using Ptolemy's boundaries or the modern ones, spans over forty degrees of the ecliptic and actually overlaps some of the stars in Aquarius.[183]

[180] From astronomer Ian Ridpath's website at http://www.ianridpath.com/startales/octans.htm accessed 11 April 2008
[181] See history on the official IAU website at http://www.iau.org/public_press/themes/constellations/ accessed 28 April 2008
[182] Confirmed visually using *Starlight* for a date of 1 January 150 CE
[183] From *Starlight*

This coinciding of the zodiac and the backdrop of the constellations was temporary, however, due to the 'precession of the equinoxes', of which Ptolemy was well aware, and credits his predecessor of some three hundred years, Hipparchus, as having discovered it.[184] As the earth spins on its daily motion, it also wobbles very slowly, so an imaginary rod sticking out of the north pole will itself describe a very slow-moving circle in the sky. This means that the backdrop of the stars appears to move relative to the earth over a very long period, taking 26,000 years to complete a cycle, so the zodiac signs and the constellations of the same name drift apart by about one degree every 72 years[185]. Ptolemy knew of this, although his figure for the drift was an underestimate, as he used a figure of one degree a century.[186]

[184] Ptolemy, *Almagest* p.131
[185] Duffett-Smith, *Easy PC Astronomy*, p.48
[186] Ptolemy, *Almagest* p.335

Cultural transmission from Babylonian to Hellenistic astrology

Although Ptolemy's works give detailed information about Hellenistic astrology, he was simply recording current practice and had not "invented" astrology, or the zodiac.[187] Many of Ptolemy's examples in the Almagest make use of 'accurately recorded ancient observations' such as his example on the correction of Saturn's periodic motion, and he highlights some examples as being 'according to the Chaldeans'.[188] Tester maintains that the Greeks believed their astrology came from Mesopotamia and that astrology was brought into Greece by the 'Chaldean Berosus'.[189]

Goldstein contends:

> By [the] second century B.C., Babylonian astronomical data reached the Greek world, although the mode of transmission is unknown. Babylonian astronomy was centuries old and, when it reached the Greeks, it was highly successful at predicting planetary phenomena and lunar eclipses: though they lacked geometrical models, the Babylonians had achieved precise knowledge of planetary and eclipse cycles, and their science was supported with copious quantitative data. The result was a radical transformation of Greek astronomy... This influx of Babylonian data and the resultant transformation of Greek astronomical science effectively obscured the earlier history of this science from later writers. As a consequence, the historian must now exercise care in relying on late testimony in his effort to understand the development of Greek

[187] Riley, "Ptolemy's Predecessors' Data" p.241
[188] Ptolemy, *Almagest* p.541 & p.13
[189] Tester, Jim, *A History of Western Astrology* (Woodbridge, Suffolk: Boydell & Brewer, 1999), p.13

> astronomy from the time of Hesiod and Homer to the time when Babylonian science intruded.[190]

Thus Ptolemy acknowledged his predecessors and there were strands of development taking place in classical Greek understanding of the cosmos at the same time that developments were taking place in Mesopotamia. However, Rochberg claims that:

> Despite the evidence of transmission and borrowing from Mesopotamia found in specific elements of Greek astrology, and that the basic idea of predicting the life of a person on the basis of astronomical phenomena associated with the birth date was originally Babylonian, Babylonian and Greek horoscopes reflect substantially different genethlialogical systems. There is neither chronological overlap between the two corpora, nor any similarity between their underlying cosmologies or their philosophical/religious underpinnings.[191]

The lack of chronological overlap is disputed, however. Rochberg herself points out that the 'latest dated cuneiform horoscope is for 69 BC, the earliest Greek horoscope is the coronation monument for Antiochus I of Commagene in 62 BC'.[192] Even by her definition, the gap between the two is only seven years. Rochberg is making the claim of no overlap purely as regards horoscopic astrology, however; as van der Waerden points out, an astrology that looks very similar to horoscopic astrology in Greece is attested almost four centuries before Rochberg's date as in this example, cited by van der Waerden, of the second century CE

[190] Goldstein, "Early Greek Astronomy", pp.339-340
[191] Rochberg, "Babylonian Horoscopes", p.2
[192] Rochberg, "Babylonian Horoscopes", p.2

Aulus Gellius (van der Waerden uses astronomical notation whereby year 1 means 1 CE, 0 means 1 BCE, -1 means 2 BCE and so on, so -441 means 442 BCE):[193]

> "A Chaldaean predicted to his father from the stars the brilliant future of Euripides".
>
> The mention of a "Chaldaean", the predictions relative to an individual and the phrase "from the stars" all point unmistakeably to horoscopy. Euripides won his first prize for tragedy at the age of 40 in -441. Since the prediction was made to his father, he must still have been young and as yet unknown. Thus, if made at all, the prediction must antedate -445.[194]

There are significant differences between the Babylonian constellations and the Greek – for example, the Babylonian "Panther" becomes a mixture of Cygnus the swan and Cepheus the King in Hellenistic astrology.[195] The zodiac constellations, however, are remarkably similar with two exceptions: the Hired Man in the Babylonian zodiac becomes Aries the Ram in the Hellenistic zodiac; and in early writings, the Greeks refer to Libra as 'the claws of the Scorpion'.[196] However, by the second century CE, Ptolemy, uses the 'claws' and the 'scales' interchangeably.[197] Libra is a pair of scales in Babylonian astrology, evidence that the Greeks adopted the Babylonian symbol in this case.[198]

In addition to the evidence that early Hellenistic astrology was influenced by Babylonian astrology, at the other end of the spectrum Campion argues that Babylonian astrological

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193 Entry for Gellius, Aulus states 'born between AD 125 and 128', *Oxford Dictionary of the Classical World*. (Oxford: Oxford University Press, 2007) Oxford Reference Online <http://www.oxfordreference.com/views/ENTRY.html?subview=Main&entry=t180.e940> accessed 24 April 2008

194 van der Waerden, *Science Awakening II*, p.181

195 Hunger & Pingree, *Astral Sciences*, p.274

196 Hunger & Pingree, *Astral Sciences*, p.273

197 Ptolemy, *Tetrabiblos*, I.9 p.51 footnote 2

198 Hunger & Pingree, *Astral Sciences*, p.275

methods were still being used in Hellenistic astrology as late as the fifth century CE, where he analyses a chart for the coronation of Leontius in July 484 CE, where using the general rules of Hellenistic astrology, it would be considered ‘inauspicious’.[199] Since the time of the coronation was supposedly elected by Leontius’ astrologer, Campion argues that the Babylonian concepts of a more visual astrology, with the chart showing a bright Venus in the morning sky, were being used, in accordance with principles that date back to the seventh century BCE: ‘Venus’s magnitude was especially bright at -3.2, a fact which would have held particular significance in the context of the survival of Babylonian, or more properly Near-Eastern astral religion, in the form of Ishtar worship’.[200]

So van der Waerden maintains that cultural transmission dates back to the fifth century BCE, while Campion claims that Babylonian techniques were still being used in the Hellenistic world in the fifth century CE. If these views are correct, then there is evidence that, far from being the separate systems claimed by Rochberg, cultural transmission from Babylonian to Hellenistic astrology spanned a millennium.

[199] Campion, Nicholas, “The Possible Survival of Babylonian Astrology in the Fifth Century CE: a discussion of historical sources”, in Oestmann, Günther, H.K. von Stuckrad, and D. Rutkin (eds.), *Horoscopes and Public Spheres: Essays on the History of Astrology*, (Berlin and New York: Walter de Gruyter 2005) [hereafter Campion, “Survival of Babylonian Astrology”] pp. 69-92
[200] Campion, “Survival of Babylonian Astrology”, p.84

Methodology

In order to see whether there is a clear lineage from the Babylonian astrolabes and star lists to the classical Hellenistic zodiac, it is important to analyse all relevant source material in detail and see whether, and where, they differ. This has been the bulk of the background research undertaken for this dissertation, and there are a number of methodological issues that arose when undertaking this research.

Babylonian source material

There are several stages that need to be processed in order to interpret a Babylonian text. Moustakas, writing on phenomenological research methods, explains the importance of engaging with the subject material hermeneutically. He argues that 'Hermeneutic science involves the art of reading a text so that the intention and meaning behind appearances are fully understood'.[201] I took this hermeneutic approach by translating a small portion of one of the cuneiform astrolabes myself, British Museum item K.14943.[202] This brought a number of issues to light, which enhanced my understanding of the issues and provided insights that would not have been available simply by researching the existing literature.

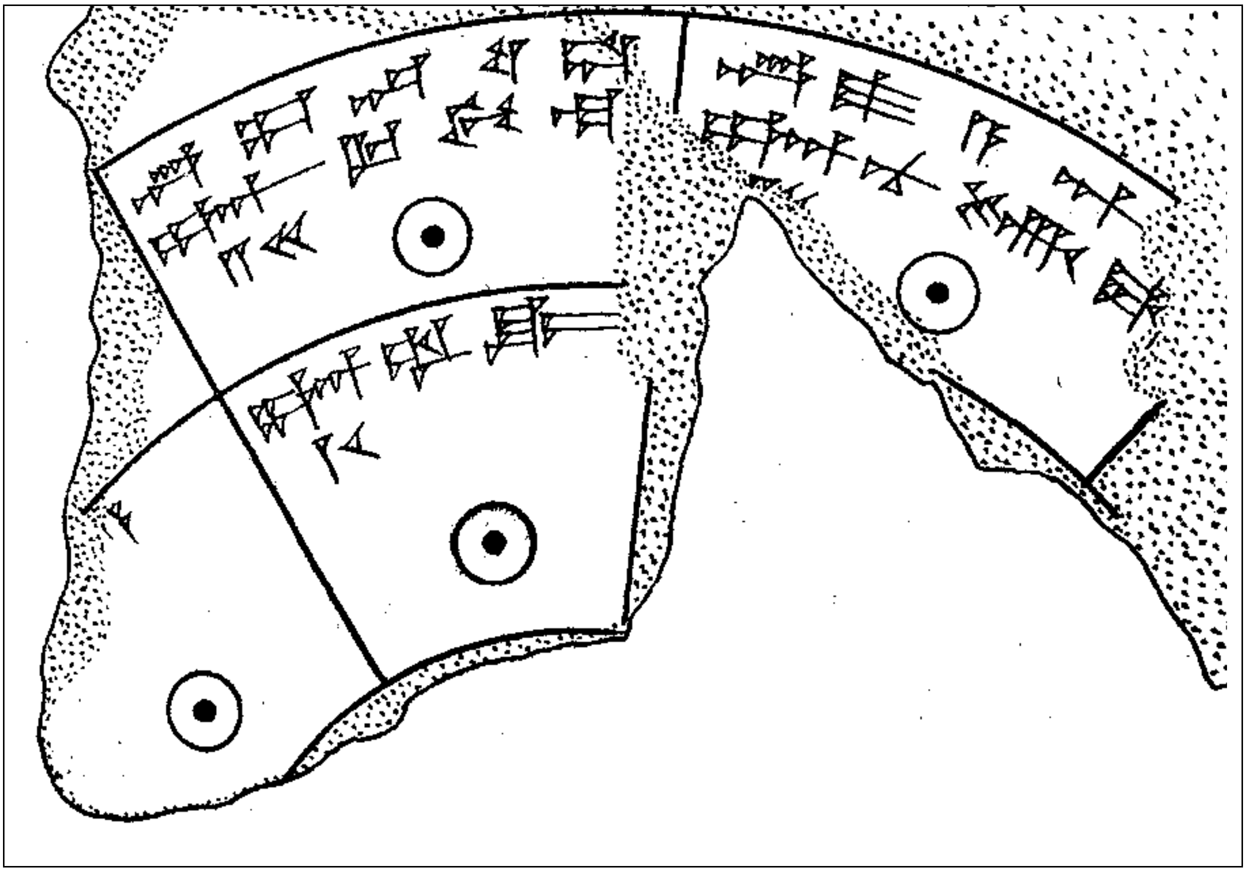
The first stage is that of transcribing the cuneiform marks on a clay tablet onto paper for further investigation. A visit to the British Museum will reveal many large stone friezes with cuneiform writing carved into them that is very clear to read; even with no knowledge of cuneiform, transcribing them onto paper would be easy. Cuneiform consists of a series of

[201] Moustakas, C., *Phenomenological Research Methods* (Thousand Oaks, CA: Sage Publications,1994) p.9
[202] British Museum, *Cuneiform Texts*, plate 12.

vertical and horizontal wedge-shaped marks, or chevron shaped marks making it relatively easy to transcribe, provided the marks are clearly visible. It is even relatively straightforward to produce a dictionary sequencing these marks, where instead of using an alphabetic sequence, the sequence runs in the form of words starting with one horizontal wedge, words starting with two horizontal wedges and moving on to words starting with triangular elements, and then vertical wedges.[203]

However, while transcription is easy for large characters pressed into clay or carved into stone, many of the astronomical tablets present two problems. Firstly, they are frequently worn so that only fragments are available; secondly, as the description given earlier for MUL.APIN states, it is written 'in a minute hand' on a tablet that measures less than 6cm x 9cm. Transcribing this onto paper is not at all easy – visually, the tablet simply looks like a series of scratches on clay rather than neat clearly defined wedge shapes.[204] The same applies to the astrolabe fragment that I translated; whereas Pinches' transcription was very clear the actual object itself was tiny, and the inscription was very difficult to see as can be seen in the following illustrations, the first being Pinches' transcription, the second the object itself:[205]

[203] See for example the sign list in Marcus, David, *A Manual of Akkadian*, (Lanham, MD: University Press of America, 1978), p.111
[204] See for example http://www.flavinscorner.com/mulapin.jpg, accessed 9 April 2008, for an image of MUL.APIN
[205] British Museum, *Cuneiform Texts*, Plate 12, and a photograph of me holding this astrolabe, taken in the British Museum, 19 November 2006



Pinches' transcription of the astrolabe fragment

Photograph of the astrolabe fragment

By watching other scholars in the British Museum, and speaking to the curator in charge of cuneiform tablets at the museum, some of the techniques used to transcribe became clear.[206] To overcome the problem of the text being written in a minute hand, transcribers worked with photographs of tablets which were then enlarged, and the transcription took place by placing a sheet of tracing paper over the enlarged photograph and laboriously tracing it with a pencil. Sometimes part of the tablet on which the text was written had become worn, and it is not immediately obvious whether a particular scratch was intended to be, for example, two horizontal strokes or a chevron shape. To overcome this problem, it is useful to understand how the cuneiform tablets were physically produced. Cuneiform was usually written on clay tablets using a reed stylus, and since a simple stylus was used and was pressed into wet clay, a very limited number of marks can be made. Where marks were unclear, the angle of the wedge could be used to determine whether, for example, two horizontal wedges were intended, or whether the scratch represented two triangular marks instead.[207] Pinches' transcription of the astrolabes is considered very good, as can be seen from the earlier quote by van der Waerden, in which he describes Pinches' transcription as 'so accurate that there is in no case any doubt as to which cuneiform sign he read'.[208]

Once the marks on the tablet have been transcribed, the second stage is to interpret the cuneiform. There are a number of complexities in this stage, not least the fact that cuneiform was originally a logographic language used to express the much older Sumerian language:

[206] The curator is Dr. Irving Finkel, biography at http://www.britishmuseum.org/the_museum/about_us/staff/middle_east/irving_finkel.aspx accessed 9 April 2008
[207] Robinson, Andrew, *The Story of Writing* (London: Thames and Hudson, 2003) [hereafter Robinson, *The Story of* Writing] p.82
[208] van der Waerden, "36 Stars", p.10

> The first clay tablets were pictographic and date, as we know, from about 3300BC; they were found at Uruk. By about 2500BC, these signs had become abstract cuneiform signs in widespread use for writing Sumerian; later they developed into the script of the Babylonian and Assyrian empires.[209]

However, the system developed into a mixture of logographic and syllabic, where certain words were made up of combinations of logograms that were pronounced as separate syllables.[210] This has led to a set of cuneiform symbols having potentially multiple meanings, where the symbol originally used for the word "sky" (AN) can sometimes be part of a word containing "an" – such as "da-an-im" (powerful), can sometimes be part of a word containing the sound "il" (the Akkadian phonetic value for the old Sumerian word for god) such as "bab-il-um" (Babylon), and can sometimes be a "determinative" indicating that the following word is the name of a god.[211] This complexity is not generally an issue for scholars.[212] However, while there is expertise in translating Babylonian texts available, most language scholars are not well versed in astronomy or astrology and so misunderstandings or misinterpretations can arise.[213]

Although there is agreement between various authors on many of the constellation names in the Babylonian texts, as in the examples given earlier where MUL.MUL refers to the Pleiades, there are other examples where this is not true. Sometimes this has just been speculation on the part of an author, and in other cases it is because assumptions have been made that have not necessarily been justified. For example, the Pinches' astrolabe

[209] Robinson, *The Story of Writing*, p.71
[210] Caplice, *Akkadian*, p.5
[211] Caplice, *Akkadian*, p.6, see also Prince, J. D. and Budge, E. A. W., *Assyrian Primer and Assyrian Texts* (Chicago: Ares Publishers Inc, 1978) p.6 logogram 76
[212] There are universities offering courses in Akkadian, such as the School of Oriental and African Studies at the University of London. See for example their course "Introductory Akkadian", http://www.soas.ac.uk/courseunits/155900426.php accessed 9 April 2008

reconstructed from the fragments outlined in the 1912 British Museum paper is often depicted with a transcription by Schott in which he translates the star 'MUL AL.LUL' as 'Equuleus?'.[214] On the other hand, van der Waerden states categorically that 'these researches enable us to identify with certainty the following constellations… AL.LUL=Procyon', although *Starlight* shows that Procyon had a right ascension of 5h00 in 1000 BCE and Kitalpha, the brightest star in Equuleus had a right ascension of 18h43 putting it in the part of the sky almost opposite Procyon.[215] The word AL.LUL means "crab" and in Hellenistic times, Ptolemy refers to Καρκινος ("karkinos"), the crab, which is translated 'Cancer' in the English while *Almagest* puts Procyon firmly in the constellation of Canis Minor, describing Procyon as 'The bright star just over the hindquarters, called Procyon'.[216] These anomalies are revealing, because they show that translations are not always clear-cut and are sometimes based on assumptions that may not be true.

Schott gave no reason for associating AL.LUL with Equuleus; indeed, the fact he put a question mark after the name suggests that he was not certain of the attribution. However, there is a logic behind his attribution. The Pinches' astrolabe shows three stars for each month, and in most cases, the stars shown are those that are rising just before the Sun for that month.[217] This can be verified for most months. For example, in month two, Ajjaru, the star 'MUL.MUL' is listed. There is agreement, as has been shown, that MUL.MUL refers to the Pleiades. The main star of the Pleiades, Alcyone, could first be seen to rise with the Sun on around 27 April, if a year of 1000 BCE is assumed and a latitude of 36ºN.[218] The new year

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213 From a personal conversation with Dr. I. Finkel, curator at the British Museum, November 2006
214 van der Waerden, "36 Stars", p.9
215 van der Waerden, *Science Awakening II*, p.73
216 Meaning of AL.LUL given in Hunger & Pingree, *MUL.APIN*, p.41; Translation of Καρκινος see for example, Ptolemy, *Tetrabiblos* I.9, p.49; placement of Procyon see Ptolemy, *Almagest*, p.388
217 van der Waerden, "36 Stars", p.12
218 From *Starlight*

was considered to start in the month of Nisannu which began around the spring equinox so the second month would be consistent with an April date.[219]

Schott, when translating the Pinches' astrolabe, can be argued to have confirmed which stars would be rising each month. For the tenth month, Tebetu, corresponding roughly to January, the stars in the region of the sky corresponding to Aquarius and Equuleus would be rising; for example, Kitalpha, the main star of Equuleus, had an apparent heliacal rising of 9 January in 1000 BCE, and Sadalsuud, one of the brighter stars in Aquarius, had an apparent heliacal rising of 18 January.[220] The astrolabe itself, however, gives two constellations for this month that do not seem to fit, UR.GU.LA and AL.LUL, and one that does fit, A.MUSHEN.[221]

A.MUSHEN means the Eagle.[222] Hunger and Pingree relate this to the bright star α Aquilae, Altair, as does van der Waerden.[223] The attributions of UR.GU.LA and AL.LUL to other stars in the vicinity of Altair is therefore logical when one is looking for stars rising at about the same time. However, UR.GU.LA means "large animal" and probably refers to a lion, and AL.LUL, as has been seen, means "crab".[224] Hunger and Pingree make the claim that 'one must correct UR.GU.LA to GU.LA', where GU.LA means "Great One" and refers to Aquarius, and Schott's decision to find another constellation in the correct path and in roughly the right area of the sky would arguably have led him to assign Equuleus to AL.LUL.[225]

[219] van der Waerden, *Science Awakening II*, p.47
[220] From *Starlight*
[221] van der Waerden, "36 Stars", p.9
[222] Hunger & Pingree, *MUL.APIN*, p.44
[223] Hunger & Pingree, *Astral Sciences*, p.93; van der Waerden, *Science Awakening II*, p.73
[224] Hunger & Pingree, *MUL.APIN*, p.41
[225] Hunger & Pingree, *MUL.APIN*, p.12; van der Waerden, *Science Awakening II*, p.76

However, these assignments are based on the assumption that the constellations in question could not possibly have been the obvious ones, Leo and Cancer, since Leo and Cancer do not rise heliacally in January. Regulus, the brightest star in Leo, for example, could be seen to rise heliacally on 6 August in 1000 BCE, and the stars of Cancer rose in July 1000 BCE.[226] This assumption seems to have been based on the idea that the astrolabes must be consistent and logical; the idea is so strong that Hunger and Pingree assume that the scribes were wrong and that one must 'correct' their errors. This assumption of logic may be an example of the 'Hellenophilia' which Pingree himself complains about, as described earlier, where academics have a "Greek mindset" and assume a rational logical approach in ancient texts.

From a visual perspective, there is potentially a very good reason for including Cancer and Leo in the bright stars of January. The part of the sky visible just before sunrise that time of year to the east has a paucity of bright stars. Altair is the one bright star on the eastern horizon, and that is listed on the astrolabe, as has been shown. The stars of Equuleus and Aquarius are not very bright – the brightest star in Equuleus has a magnitude of 3.92 making it very faint, and even the brightest stars of Aquarius, Sadalmelek and Sadalsuud, do not exceed 2.9 in magnitude; these are faint stars too.[227] From an observational perspective, trying to locate faint stars in the east at sunrise would be very difficult. However, turning round and looking at the stars setting on the western horizon would give a very different picture – the bright stars of Leo, and the fainter but still visible stars of Cancer would be seen very clearly; the morning setting of the star Acubens in Cancer was 12 January in 1000 BCE and the morning setting of Regulus in Leo was 18 January.[228] The evidence that the Babylonians may have altered the general rule for this month is also very clear in MUL.APIN itself. The text lists morning risings specifically, and starts: 'On the 1st of Nisannu the Hired Man becomes

[226] From *Starlight*
[227] From *Starlight*

visible. On the 20th of Nisannu the Crook becomes visible', suggesting the importance of heliacal rising stars.[229] However, for the month of Tebetu it states: 'On the 15th of Tebetu SIM.MAH, (i.e.) the Swallow (or) IM.SES, becomes visible in the East, and the Arrow becomes visible in the evening', showing that an interest in setting stars is also relevant, especially in the month when most of the rising stars are very faint.[230] This highlights one area where interpretation may not be straightforward, as it may be based on assumptions made by the translators.

Another issue is the question of accuracy. As has been illustrated earlier, debate rages about the dating of texts like MUL.APIN, with estimates varying from 2300 BCE to 700 BCE. Dating has been done by matching the descriptions and dates in the text with reconstructions of the night sky at various dates, but there is a problem in deciding how to translate a Babylonian date to a modern date so that a reconstruction of the sky can be made. In particular, the "fifteenth" of a month (which by definition has to be around the time of the full Moon, since Babylonian months always started on the day of the first visibility of the crescent Moon) can vary from one year to another by up to two weeks – and since heliacal rising dates are highly sensitive, this impacts on dating the MUL.APIN and identifying the stars it refers to. For example, consider the line in MUL.APIN that says 'On the 1st of Ajjaru the Stars become visible'.[231] It has been stated earlier that there is a consensus that 'the Stars', MUL.MUL, refers to the Pleiades, a grouping small enough that the star Alcyone can usefully be taken as a reference point without any ambiguity. Ajjaru is the second month, and the first month begins around the spring equinox as has already been stated.[232] In the year 707 BCE, the spring equinox fell on 28 March and a new Moon occurred on 30 March but the first

[228] From *Starlight*
[229] Hunger & Pingree, *MUL.APIN*, p.40
[230] Hunger & Pingree, *MUL.APIN*, p.46
[231] Hunger & Pingree, *MUL.APIN*, p.40

sighting of the crescent Moon would not have been visible until around sunset on 31 March.[233] This date would be the start of the new year, the first of Nisannu. Thus the second month, the first of Ajjaru, would have taken place at the next new Moon, 29 April 707 BCE. An observer watching for stars rising just before the Sun the next morning would indeed have seen the Pleiades rising; the astronomical heliacal rising (when the star rises exactly with the Sun) takes place on 15 April in 707 BCE, but this wouldn't have become visibly the case until around 30 April when the Pleiades rise about 40 minutes before the Sun (the exact date depends on weather conditions).[234] However, 30 April is consistent with the text of MUL.APIN, so a date of 707 BCE would certainly be viable for the text. MUL.APIN, though, does not specify a year. Going back a few years to 711 BCE, the spring equinox again falls on 28 March, but this time there is a full Moon, so the new year would not start until the following new Moon, two weeks later. This makes the first of Nisannu, the new year, 13 April 711 BCE, so the first of Ajjaru would take place on 12 May 711 BCE. On this date, the Pleiades rise 75 minutes before the Sun. Now consider the extreme case that van der Waerden supports, namely that MUL.APIN may have been written as early as 2300 BCE. In 2309 BCE, the spring equinox fell on 9 April, with the new Moon – the first of Nisannu – falling on 11 April. The second month would fall on 10 May. The following morning, the Pleiades rose 90 minutes before the Sun. In 2294 BCE, the equinox fell on the day of a full Moon, so Nisannu did not start until 24 April, meaning that the first of Ajjaru started on 24 May. By this date, the Pleiades rose over two hours before the Sun, and it would be far more logical to give the bright red eye of the Bull – Aldebaran – the honour of being the heliacal rising star, since this would be clearly visible just before dawn.

[232] van der Waerden, *Science Awakening II*, p.47
[233] Dates and lunar phases calculated from *Solar Fire*; visibility confirmed by *Stellarium*
[234] Astronomical and visible heliacal rising dates from *Starlight*

The parameters here are very wide. A difference of 1600 years (between 700 BCE and 2300 BCE) shifts the heliacal rising of the Pleiades by about six days.[235] However, this cannot be used for dating MUL.APIN accurately, because the actual start date of each year, based on the new Moon, can be out by up to fifteen days. In addition to taking calendar differences into account, the visibility of a star at dawn will depend upon a number of factors – atmospheric conditions, magnitude of the star, and the time of year. Similarly, the terms used in MUL.APIN are rather vague; the instructions for observing 'ziqpu' (culminating) stars reads:

> If you are to observe the ziqpu, you stand in the morning before sunrise, West to your right, East to your left, your face directed towards South; on the 20th of Nisannu the kumaru of the Panther stands in the middle of the sky opposite your breast, and the Crook rises.[236]

If the observer is facing south as instructed, it is not entirely clear what the term 'opposite your breast' means. It could mean the star to be viewed must be precisely on the meridian, or it could be that a few degrees either side is acceptable. Equally, it could be that 'opposite your breast' indicates something about the altitude of the star, so that a star culminating at the desired height (opposite the observer's breast at eye height) is more important than it being due south, in other words the altitude may be as significant as the azimuth – none of this is clear from the text. MUL.APIN also uses confusing terminology that seems to imply *a priori* knowledge on the part of the reader. For example, the term 'Frond of Eru' is used when describing the stars in the path of Enlil: 'the Frond (of the date palm) of Eru, Zarpanitu' and on other occasions Eru is mentioned alone: 'Nimru u Eru inappabuma (The Panther and the

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235 From *Starlight*
236 Kimaru translated as "shoulder" according to Hunger & Pingree, *Astral Sciences*, p.85; Hunger & Pingree, *MUL.APIN*, p.61

Eagle rise)'.[237] These compounded issues with their associated errors can accumulate, making it very difficult to date MUL.APIN, or to determine constellation boundaries precisely.

Despite these inherent errors, the perception that Greek astronomy was mathematical while while Babylonian astronomy was visual may not be valid. This image is exemplified in some of the earlier quotes in the introduction, especially by Kline in quoting the apparent lack of mathematical theory prior to the Greeks. However, even Kline concedes that the Babylonians were able to solve complex mathematical problems relating to astronomical observations.[238]

Neugebauer points out that the main difference between Babylonian and Greek astronomy was that while Greek astronomy saw the movements of planets as being a continuous function of time, Babylonian astronomy 'concentrated on specific events, e.g. new moons, or consecutive stationary points for a planet'.[239] Babylonian mathematics was advanced. While they didn't have trigonometry like the Greeks, they were able to get very accurate results using a series of arithmetic progressions (usually using a linear zigzag function) to arrive at the same results.[240] Indeed, modern computers work out trigonometric functions in a very similar way and yield extremely accurate results[241].

The sexagesimal notation that Ptolemy uses itself is a Babylonian invention. It was the Babylonians who divided the year into twelve months, the day and night into twelve hours each, and the circle into 360 degrees. It is because of the Babylonians that we today have hours divided into sixty minutes of sixty seconds each, as pointed out by Neugebauer:

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[237] Hunger & Pingree, *MUL.APIN*, p.21 & p.51
[238] Kline, *Mathematical Thought*, p.9
[239] Neugebauer, *HAMA*, p.373.
[240] Neugebauer, *HAMA*, p.374
[241] See for example Steidl, G. and Tasche, M., "A Polynomial Approach to Fast Algorithms for Discrete Fourier-Cosine and Fourier-Sine Transforms", *Mathematics of Computation*, Vol. 56, No. 193 (Jan., 1991), pp. 281-296

> The texts divide the day into 360 units call uš, meaning originally "length". Obviously, the uš are the units called "time degrees" by the Greeks such that 1 day = 360º. It is important to note that these units are of constant length, in contrast to the "seasonal hours" of the Greeks. The counterpart to the Babylonian time degrees are the "equinoctial hours". It is from the combination of the Babylonian sexagesimal norm with the 12-division of night and daytime in Egypt that Hellenistic astronomy developed the division of the day in 24 equinoctial hours which we are still using today.[242]

The accuracy of their calculations meant that the Babylonians were capable of using calculations to work out the positions of planets and stars; their astronomy may have been visual initially, but they certainly knew how to work out positions non-visually.[243]

The mathematical techniques employed by the Babylonians were, therefore, quite sophisticated, and the difficulty from our modern perspective of attempting to use MUL.APIN to define the way in which the Babylonians divided up the sky stems not from the lack of accuracy in the mathematics, but in uncertainties relating to dating the text itself, and in the "ideal" calendar used in MUL.APIN. If an argument is to be made that the division of the sky by the Babylonians ultimately led to the development of an equal-sign zodiac, then it is important to be able to define the divisions, and hence the boundaries, of the constellations used by the Babylonians. The source material covered so far – namely, the astrolabes and MUL.APIN – gives a few hints of a neat twelve-fold division as was seen in van der Waerden's argument that the zodiac was 'in the wind' at the time. However, a clear definition

[242] Neugebauer, *HAMA*, p.367
[243] Neugebauer, *HAMA*, pp.420-497

of boundaries is lacking, as Hunger and Pingree demonstrate when they suggest that some of the stars listed in the MUL.APIN describing Scorpio may extend into the constellation we know as Libra, because we do not know what boundaries were used.[244]

Fortunately, in addition to MUL.APIN, there are records of much later Babylonian texts where the dates in question are far easier to determine; in particular, astronomical diaries dating from the fourth century BCE.[245] These are dated, by reference to the number of years the king had been on the throne, and so it is possible to date these accurately. For example, there is a list of Jupiter observations from 'year 18 of Aršu who is called king Artxerxes', referring to the eighteenth year of Artaxerxes II, equivalent to 387 BCE to 386 BCE.[246] The fact that a specific date is given in these texts means that it is possible to compare these records to the positions of Jupiter as calculated by software, and to glean information about Babylonian constellations or signs. The notation used in the diaries is consistent in that it lists the month, and a date in that month where a significant Jupiter observation is made. As an example, the following observations of Jupiter demonstrate how we can discover the boundaries of Pisces. On one particular tablet relating to 'Year 18 of Aršu', line three reads 'Month V, the 30th. the 28th, acronychal rising'.[247] As stated in the 'Calendar' section of this dissertation, the new year began around the spring equinox at the first sighting of the crescent Moon. Month V is therefore around August in the Western calendar. Hunger explains that 'the 30th' is simply his shorthand for 'the first of the month, the previous month having 30 days' since a month can have either 29 or 30 days in the Babylonian calendar.[248] So the significant part of this line is '28th, acronychal rising', which means that on the twenty-eighth

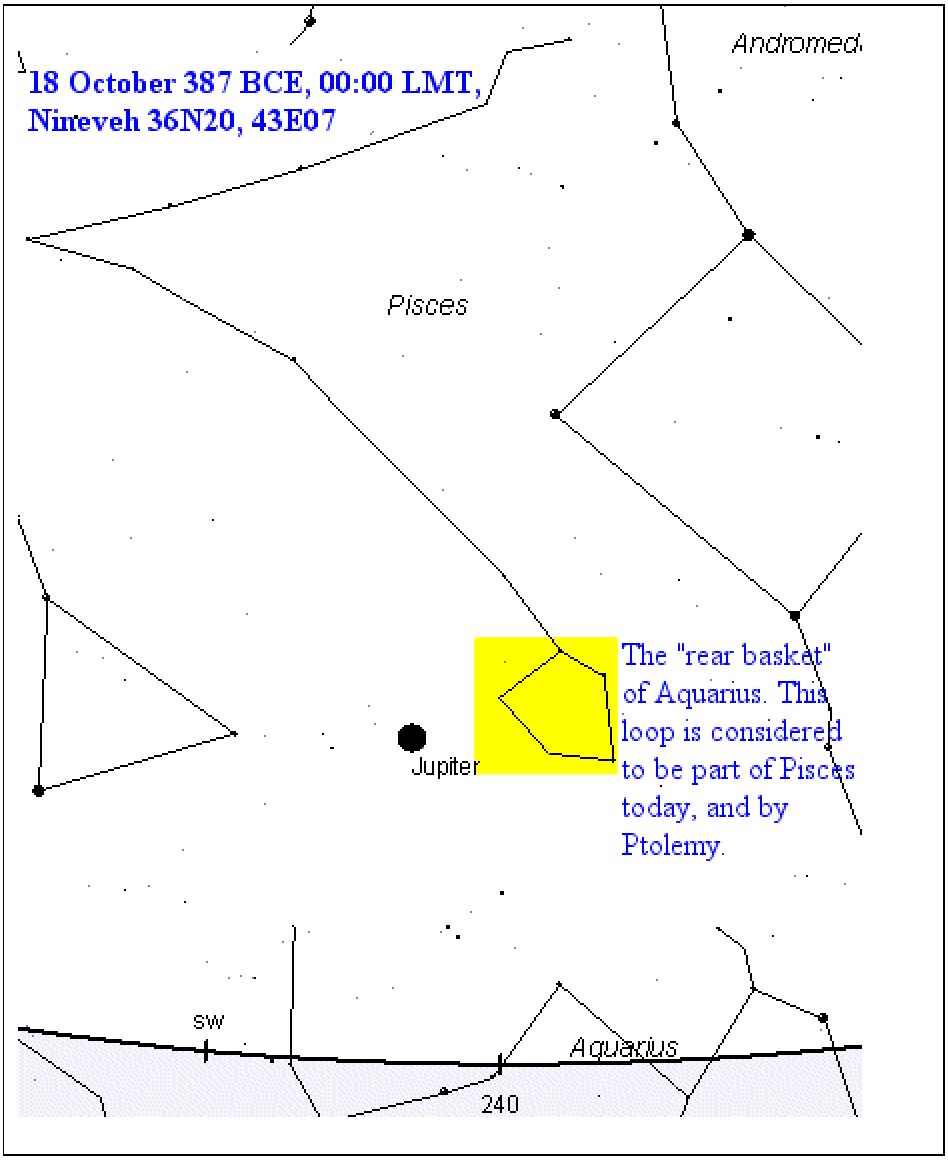
[244] Hunger & Pingree, *Astral Sciences*, p.54
[245] Hunger, H. ed. *Astronomical Diaries and Related Texts from Babylonia, Vol V, Lunar and Planetary Texts* (Vienna: Verlag der Österreichischen Akademie der Wissenschaften, 2001) [hereafter Hunger, *Astronomical Diaries*]
[246] Hunger, *Astronomical Diaries*, No. 60, p.210
[247] Hunger, *Astronomical Diaries*, No. 60, p.210
[248] Hunger, *Astronomical Diaries*, p.210

day of that month, Jupiter could be seen to rise as the Sun set. Since the month starts on the first sighting of a crescent Moon, which is when the Moon is around 15º ahead of the Sun (this can be confirmed using any planetarium software such as *Stellarium*), then the twenty-eighth day of the month can be found by using software to see when the crescent Moon appeared in August 387 BCE, and treating that as the first day of the month. I used *Solar Fire* to see when the first visibility of the new Moon occurred, counted this as the first day of the month and counted forward to derive the date of day 28 of month V, which is 26 August 387 BCE. Using *Starlight*, it was easy to confirm visually that Jupiter did rise just after the Sun set; Jupiter rising at 18:54 at a latitude of 36ºN, and the Sun setting at 18:46. This does not tell us anything about boundary conditions at this point, but it does confirm the methodology works.

The next two lines are significant for deriving boundary conditions: 'Month VII the 30th until around the 23rd, when it became stationary to the west, the rear basket of Aquarius'.[249] The term 'stationary' refers to the fact that planets appear to have a daily motion against the backdrop of the stars when observed day after day, but will sometimes appear to slow down and subsequently go backwards (called 'retrograde'). The point when the planet appears to stop moving is called its 'station', and measuring it visually is difficult because the daily motion of a planet as it stations is extremely small.[250] Using the same dating technique, day 23 of month VII equates to 18 October 387 BCE. *Solar Fire* shows that Jupiter actually went stationary on 24 October, but since the daily motion of Jupiter is around a minute of arc a day when it nears station, this six day difference is understandable.[251] *Solar Fire* shows that the position of Jupiter at its station was 23º31' Aquarius, and *Starlight* shows Jupiter sitting by a

[249] Hunger, *Astronomical Diaries*, p.210
[250] *Solar Fire* was used to calculate stations and daily motion; definition of stationary planet from Ridpath, *Dictionary of Astronomy*, entry for "stationary point" accessed online 26 April 2008 http://www.oxfordreference.com/views/ENTRY.html?subview=Main&entry=t80.e3559

group of stars which in today's star catalogues are considered to stars in the "loop" of the constellation Pisces:[252]

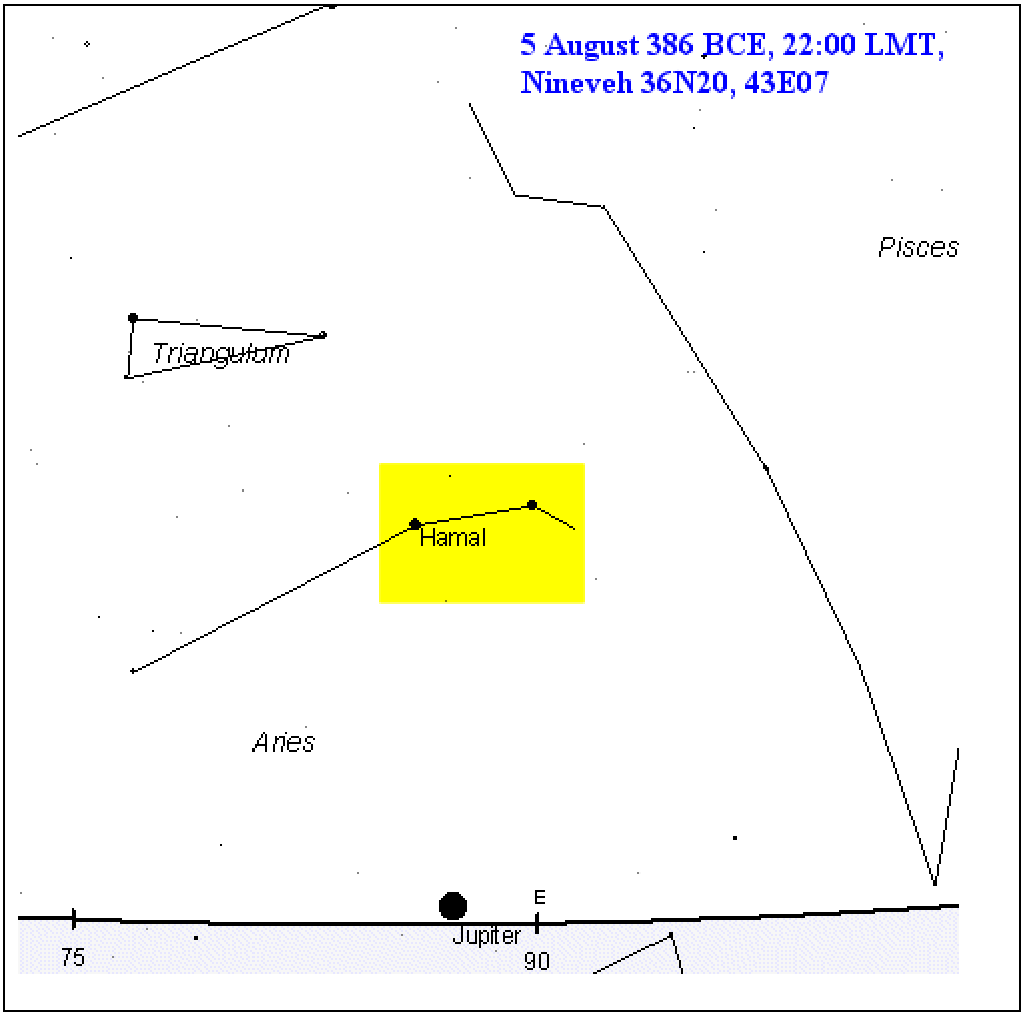


Jupiter stationing by the "rear basket" of Aquarius

[251] *Solar Fire* was used to calculate daily motion
[252] Output for this and subsequent illustrations of constellations from *Starlight*

However, the Babylonian text describes this location as 'the rear basket of Aquarius' (this is Hunger's translation – the original text uses the word 'GU', 'the great one' for Aquarius), so it appears that this star group was considered by the Babylonians to be part of the constellation Aquarius, not Pisces. This is also confirmed by Hunger and Pingree, who identify the constellation 'The Great One' with Aquarius, and the star called 'Front basket of Great One' with phi or chi Aquarii in the constellation of Aquarius, but the star called 'Rear basket of Great One' as lambda Piscium in the constellation of Pisces.[253] Another boundary condition is given for the following year, where for month IV on the 19th 'it became stationary to the east below the beginning of Aries'.[254] The dating technique described above gives this date as 5 August 386 BCE, confirmed by *Solar Fire*, which gives 4 August as the date of Jupiter's station. *Starlight* shows the planet Jupiter sitting just below the two main stars of the constellation Aries:

[253] Hunger & Pingree, *Astral Sciences*, p.273
[254] Hunger, *Astronomical Diaries*, p.210



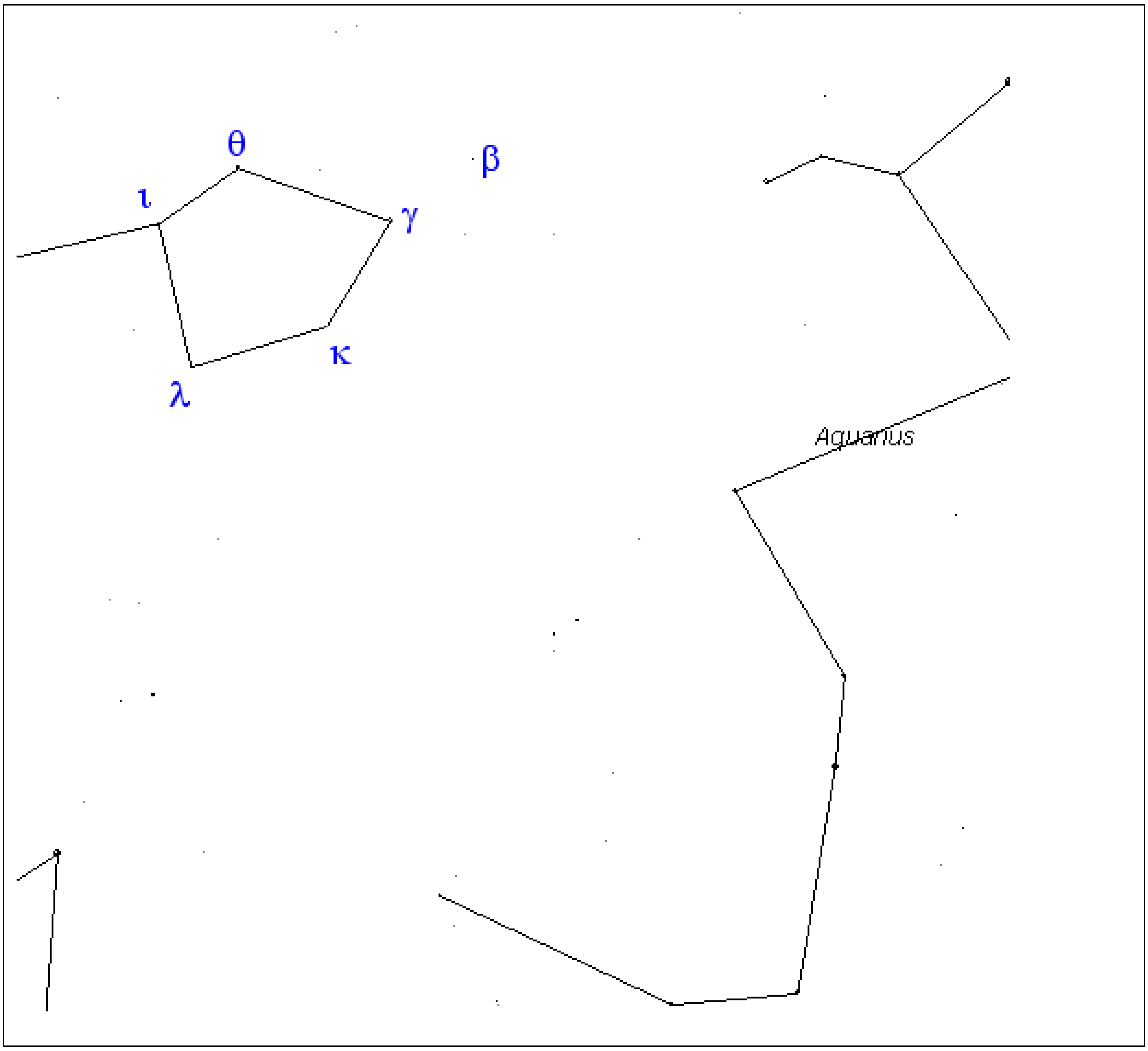
Jupiter stationing "below the beginning of Aries"

Thus these techniques demonstrate that the Babylonian definition of the boundary between Aquarius and Pisces does not seem to agree with our current definition, whereas the Babylonian definition of the boundary between Pisces and Aries does appear to agree with the modern definition of this boundary.

Hellenistic source material

To be able to answer the question of whether the zodiac was developed in Babylonian astrology and transmitted to Hellenistic astrology, it is important to know what constituted the boundaries of the segments of sky that were used to identify the positions of planets, whether these were zodiacal signs or rather looser constellations. The section above shows that while some of the boundaries defined by the Babylonian texts do appear to correspond, at least roughly, to the modern definitions of these boundaries (such as the boundary between Pisces and Aries), not all of them do so (for example, the boundary between Aquarius and Pisces). The example given in the 'Zodiac and constellations' section of this dissertation illustrates that the modern definition of constellation boundaries corresponds very closely to the definitions that Ptolemy gave in *Almagest*, and so the definition of the boundary between Aquarius and Pisces appears to have changed some time between the fourth century BCE when the *Astrological Diaries* were written, and the second century CE, when Ptolemy wrote *Almagest*. This suggests that the Babylonians did not have the same concept of Aquarius and Pisces as did Ptolemy. To Ptolemy, the loop formed by the stars beta, gamma, theta, iota, kappa and lambda Piscium were all stars 'in the advance fish', whereas to the Babylonians these same stars appear to have constituted the 'rear basket' of Aquarius:[255]

[255] Ptolemy, *Almagest* p.379



The "loop" of Pisces with the modern nomenclature for these stars, which were considered to constitute the "rear basket" of Aquarius by the Babylonians, and the "advanced fish" of Pisces by Ptolemy.

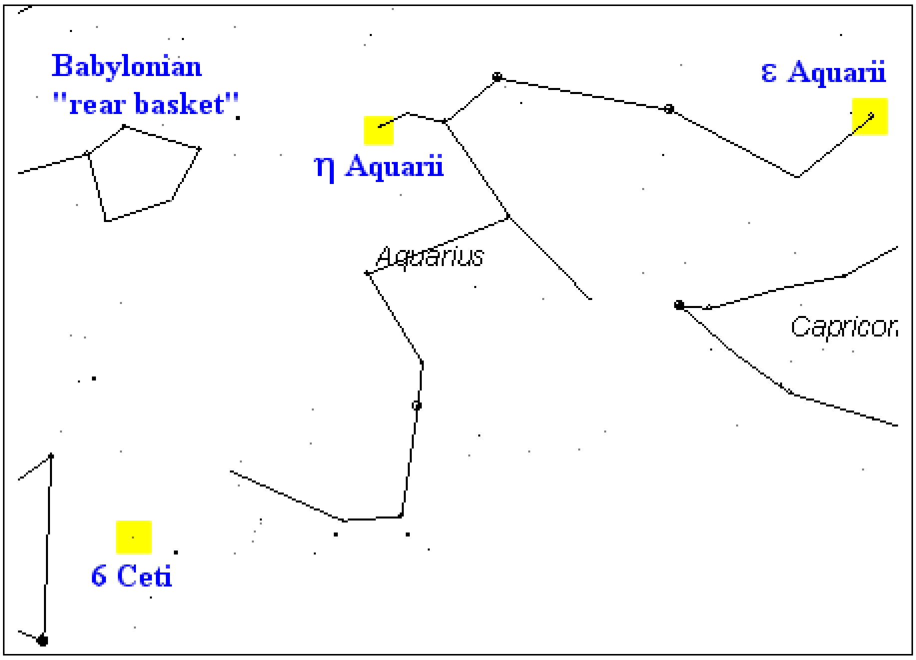
By looking at lists of rising times (from the parapegmata) in early Hellenistic writing, and taking precession into account, it may be possible to calculate the boundary stars for constellations for the earlier Hellenistic model. Eudoxus composed a parapegma and Geminos also has an appendix giving a parapegma based on earlier observations.[256] These can be used to determine the boundaries of constellations and then measured to see if differences arose between these early writers and Ptolemy in *Almagest*, or to see to what extent the parapegma of Geminos coincided with Ptolemy's.[257] Geminos was using Greek sources going back to five centuries before Ptolemy, and his parapegma makes reference to Euktemon who made his observations around the year 400 BCE and Kallippos who made his observations around 330 BCE:[258]

> The Sun passes through Aquarius in 30 days. On the 3rd, according to Euktemon, the Lyre sets in the evening; rainy…On the 17th, according to Euktemon, it is time for the west wind to blow. According to Kallippos, Aquarius rises to its middle…[259]

Using *Starlight* to check these observations, one can see that on the third day of Aquarius in the year 400 BCE (27 January 400 BCE) Vega, the main star of Lyra, the Lyre does indeed set about half an hour after the Sun, set for the latitude of Athens, so the parapegma seems correct in this instance.[260] Now setting the date for the 17th day of Aquarius in 330 BCE (since we are referring now to a later observer, although the 70 years difference will only affect positions by about a degree due to precession), the star that is rising with the Sun (using the criteria of visibility rather than astronomical rising) is eta Aquarii.[261] This star visually looks as though it is at the very edge of the modern constellation of Aquarius, rather than the middle; if we allow for the loop of Pisces being part of the constellation of Aquarius, as the Babylonians did, then that star is indeed roughly in the middle of Aquarius, which may suggest that in the fourth century BCE the Greeks were using a similar definition of constellation boundaries to the Babylonians. However, this weak evidence. The constellation of Aquarius as described by Ptolemy includes some stars that modern textbooks put into

[256] van der Waerden, *Science Awakening II*, p.290; Evans & Berggren, *Geminos*, pp.231-240
[257] Ptolemy did not produce a parapegma as such, but his definitions of constellation boundaries were, as as has been seen, very clear.
[258] van der Waerden, *Science Awakening II*, p.13 & 105
[259] Evans & Berggren, *Geminos*, p.237
[260] Rükl, *Guide to Stars* p.176
[261] From *Starlight*

Cetus, and so Ptolemy's Aquarius spans from 14°40' of the zodiac sign of Capricorn (epsilon Aquarii) to 29°40' of the zodiac sign of Aquarius (6 Ceti), so eta Aquarii at 13°30' of the zodiac sign of Aquarius is about two-thirds of the way through the constellation. Depending on how loose Kallippos' definition of 'the middle' is, while the Babylonian definition looks promising since the star Kallippos refers to is roughly in the middle, Ptolemy's definition of the constellation could also be valid. Thus in this instance, it is impossible to say for certain whether by the time of Kallippos the shift of perception of what constituted the stars of Pisces and Aquarius had been made:



η Aquarii appears to be almost at the edge of the modern constellation of Aquarius (shown by the stick figure). It would be in "the middle" if we take the Babylonian "rear basket" to be part of Aquarius. However, Ptolemy did not include the rear basket, but he did include the star now called 6 Ceti as part of Aquarius, so arguably η Aquarii could still be said to be "in the middle" of the constellation of Aquarius.

Conclusion

There are, then, two traditions that by the second century BCE have become intermingled – the Babylonian tradition of cataloguing the rising and setting of stars and forming them into constellations, dating back to the astrolabes and MUL.APIN, and a similar tradition in Greece dating back to the eighth century BCE.

If the constellations are of much older provenance and were already in use by the time Mesopotamian astronomers wished to devise a system for stating the positions of planets, there would be no reason to suppose that each constellation should be exactly thirty degrees. However, if the constellations were named as part of a process of dividing the ecliptic into equal segments for the purposes of being able to identify a location in the sky where a particular phenomenon took place, then there would be an argument for choosing boundary stars that made each constellation span thirty degrees.

It has been shown that the zodiac appeared to have its origins in Mesopotamia in around the fifth century BCE, where the zodiac signs were given the same names as the constellations that they contained. As demonstrated in the introduction, an assumption runs through existing literature that these constellations were unequal in size, and that the development of a zodiac of twelve equal signs was an attempt to rationalise this.

It has also been shown that the zodiac as adopted by the Greeks, and defined in detail in Ptolemy's *Tetrabiblos*, is based on the Babylonian zodiac in so far as the zodiac names share very similar names, and that the concepts involve a division of the ecliptic into twelve equal segments.

The assumption that the constellations were not of equal size certainly holds true by the definitions used by Ptolemy. The detailed description in Ptolemy's *Almagest* of each constellation, including the twelve zodiacal constellations, shows that by the second century CE the boundaries of the constellations were clearly defined, and that these constellations did not all span exactly 30º of the ecliptic, as stated in the introduction to this dissertation. Thus the Hellenistic zodiac of twelve 30º signs is not the same as the Hellenistic notion of the irregular constellations after which the zodiac signs are named.

There are two questions that have been addressed. Firstly, whether the division of the year by the Babylonians into twelve months led to the adoption of an equal twelve-sign zodiac, which was then incorporated into Hellenistic astrology, and secondly to develop this idea to see whether the Babylonians preceded the idea of dividing the ecliptic into twelve theoretical equal segments by choosing boundary stars for their constellations such that each constellation also spanned thirty degrees.

There has been some evidence presented in this dissertation to support the latter idea, but it is by no means conclusive, mainly for the reasons of a paucity of source material, and because of the problems outlined in the 'Methodology' section in terms of dating texts and a lack of knowledge of the intentions of the writers of those texts as regards the level of accuracy. A single example has been shown, in the Babylonian definition of the constellations of Pisces and Aquarius, where it has been demonstrated that a number of stars which Ptolemy considered to be part of the constellation of Pisces appear to have been considered by the Babylonians to be part of the constellation of Aquarius. If this is the case, then the boundary star between Aquarius and Pisces would be omega Piscium, and rather than spanning almost forty degrees as defined by Ptolemy, the Babylonian constellation of Pisces would indeed have spanned thirty degrees.[262]

In the question of the division of the year by the Babylonians leading to the development of an equal sign zodiac, however, the evidence is stronger. The relationship between Babylonian astrology and the adoption of many of its ideas, including the zodiac, into Hellenistic astrology is clear. The Greek writers such as Ptolemy directly acknowledged the Babylonian origin, and Hunger and Pingree give an example of Babylonian texts having echoes in Homer's *Iliad*, describing the shield of Achilles.[263]

The division of the year into twelve by the Babylonians, accredited by them to the god Marduk who 'made the year, divided its boundaries, 12 months…', the fact that MUL.APIN is based on an idealised twelve month calendar rather than the civil twelve or thirteen month lunar calendar used in practice, and the division of the day and the night into twelve equal hours each all suggest that an equal division of time was important to the Babylonians.[264] The 'Methodology' section also demonstrates that as well as an equal division of time, the Babylonians also divided space into equal segments – a circle being divided into 12 beru as a 30º unit, and as Neugebauer's quote in that section indicates, the Babylonian word 'uš' refers to both an equal division of time and of space.

There are, therefore, good grounds for considering that the division of the year into twelve by the Babylonians was associated with a division of the sky into twelve, leading eventually to the creation of the twelve-sign zodiac in Babylonia, which was then adopted into Hellenistic astrology. However, far from the 'rapid development' claimed by Neugebauer and quoted in

[262] Rükl, *Guide to Stars*, p.127
[263] Hunger & Pingree, *Astral Sciences*, p.67

the ‘Review of previous literature’ section of this dissertation, this development appears to have been gradual, and may be better seen as a thread that developed from the early basic omen literature where a need to specify placements of planets arose, which then grew to incorporate a much richer system of identification, of which the twelve-sign zodiac was a part.

[264] See ‘Early indications of a zodiac’ section of this dissertation

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