The Star Zodiac of Antiquity

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In the early third century AD, two zodiac systems converged.[1] One was the ancient star-zodiac derived from the constellations, while the other was the tropical zodiac, with its beginning at 0^0 Aries firmly anchored to the Vernal Point, the Sun's position at the Spring Equinox. It will be argued here that this latter, tropical, system had not, in the third century, come to be accepted by astrologers, but that it was to gradually come into use amongst astrologers as the earlier, sidereal system sank into a deep oblivion, at least in the West, from which it did not re-emerge until rediscovered late in the nineteenth century.

It remains far from easy to ascertain which were the primary reference stars which defined the sidereal zodiac's position, and there may have been different views on this, amongst the several cultures that adopted it.[2] The term 'sidereal' derives from the Greek *sidera,* a star, and the terms 'sidereal'- and 'star'- zodiac will here have the same meaning, as alluding to a division of the ecliptic into twelve *equal* sectors. The term 'zodiac' will here be used in the sense of these twelve equal divisions of the ecliptic, and will not allude to the unequal constellations that are, as it were, behind the twelve signs.

The convergence of the two celestial wheels, tropical and sidereal, meant that the Vernal Point was moving by precession from the sidereal sign of Aries into Pisces, an event comparable to the expectations of present-day astrologers of its movement into Aquarius. These two events, one in the past and the other still in the future, are separated by a period of twenty-one centuries, the interval for the Vernal Point's movement round thirty degrees against the stellar background. However. while most histories of ancient astronomy move effortlessly from twelve unequal constellations to the tropical zodiac of equal divisions, blurring the distinctions between the two, it will be argued here that neither of these two systems was used by Hellenistic or classical astrologers for their celestial longitude positions, and that they used a third system, an intermediate stage, namely a sidereal zodiac of equal-sized divisions rather than unequal constellations. A historical perspective may be helpful.

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Early Beginnings

Early Sumerian astronomical records show how the constellations were perceived on or near to the ecliptic in relation to the Moon: seventeen or eighteen of these were discovered,[3] as listed in the seventh century BC tablet, Mul Apin, which concluded,

> These are the gods standing on the path of the moon, (the gods) through whose sectors the moon passes every month and whom he touches.[4]

The sequence began with Taurus and the Pleiades, ending with Lu.hung.ga, the Sumerian equivalent of Aries.[5] Some half a dozen of these constellations had the same names as today (the Crab, Balance, Bull, Lion, Scorpion and Goat-fish), though the images may have differed. For example, 'The Mesopotamian Bull-of-Heaven shared with our Taurus the cluster Hyades as its head but in other respects it was different'.[6] Aries was originally the Hired Farm Labourer,[7] and Aquarius was The Giant. There was a Great Swallow (south-western Pisces plus epsilon Pegasi) and a Lady of the Heavens (north-eastern Pisces plus the central part of Andromeda),[8] both of which constellations turned into fishes. These became linked to form a single sign/constellation as the zodiac came into existence.[9] An early Greek name for Libra, Chelae, meant 'horn of a scorpion', hinting at a much larger Scorpion.[10]

Few constellation-images are derived from the Chaldeans. However, one fragment shows the Virgo constellation, with an upright figure holding a sheaf of corn, and the star Spica nearby.[11] Likewise in the Denderah zodiac, of c.30 BC the sign Virgo is represented by an upright Isis-type figure.[12] There may be, shall we say, a lost story of how Ptolemy's Virgo-constellation came to be very large, no less than forty-six degrees of the ecliptic, with the Virgin laid out on her back. It was rather crucial to the definition of the star-zodiac that Spica was a boundary star, whereas the horizontal Virgo has Spica in the middle. It would seem to me (rightly or wrongly) that such a horizontal Virgo rather implies that the Sidereal zodiac has been forgotten.

As early as the second millennium BC, the Sumerians had developed a base-sixty (sexagesimal) number system, with a year containing 360 days and a day divided into 360 parts, with twelve hours and thirty 'minutes' per hour.[13] Their schematic year had twelve lunar months each of thirty

days. Such base-sixty arithmetic is today remembered by our division of an hour into minutes and seconds.

From the mid-sixth century BC the astrological/astronomical 'Diaries' record the first evidence for the zodiac: planetary ingresses in 'theoretically calculated zodiacal signs as opposed to visible constellations'.[14] Thus, in the sixth century BC a twelve-fold 'solar' logic starts to be stamped upon the hitherto irregular constellations of the ecliptic. Pressure from this logic caused the rearrangement of constellations which had been stable for at least the previous thousand years. The large Leo constellation occupying more than one sign was decapitated by its sign boundary, while several constellations perceived around what we now call Pisces were fused into one.

There is one tablet from the fifth or sixth century BC showing a calendar system of twelve months, with adjacent constellations, some months having two constellations.[15] Month II had the Pleiades and Taurus, month III had Gemini and Orion, while the last month of the tablet had Pegasus and Pisces. It does not seem clear whether the constellation thereby associated with a month was that rising just before dawn or whatever.[16] This is the earliest twelve-fold list, and as such notable for having the sequence from Aries to Pisces, i.e. the 'beginning' to its zodiac sequence appears the same as that in use today.

At the beginning of the fifth century, twelve equal 'signs' existed as divisions of the ecliptic, mirroring a schematic year of twelve months each of 30 days, whereby the Sun moved approximately one degree per day. In the fourth century a further subdivision into thirty degree intervals gives individual celestial longitudes to the stars.[17] These things were rediscovered at the end of the nineteenth century, when tablets now in the British Museum were unearthed from the banks of the Tigris and their cuneiform script deciphered. Prior to this, for one and a half millennia, the primal, star zodiac had been forgotten. It seems that only much later on, in the mid-second century BC, did the idea of dividing a circle into three hundred and sixty degrees first appear, in Greece.[18]

The Metonic cycle was first used in the fifth century BC for calendar computations, first in Chaldea and then in Greece,[19] whereby the twelve lunar months were kept in step with the solar year through nineteen-year intervals. Before this, the process of intercalation had been a quite haphazard affair. The calendar acquired a structure linking months and years, at the same historical moment as twelve equal signs became fixed in the firmament.

The Greek word κοσμοζ (Kosmos) originally meant 'order' or 'adornment', from which the word 'cosmetic' derives. Then, in or around the fifth century BC, it came to acquire a more special meaning, as applying to the ordering of things as a whole,[20] this being in opposition to the concept of 'chaos'. Thus, the meaning of the word kosmos, of beauty as discerned in the order and structure of the world, developed while the zodiac was coming into being.

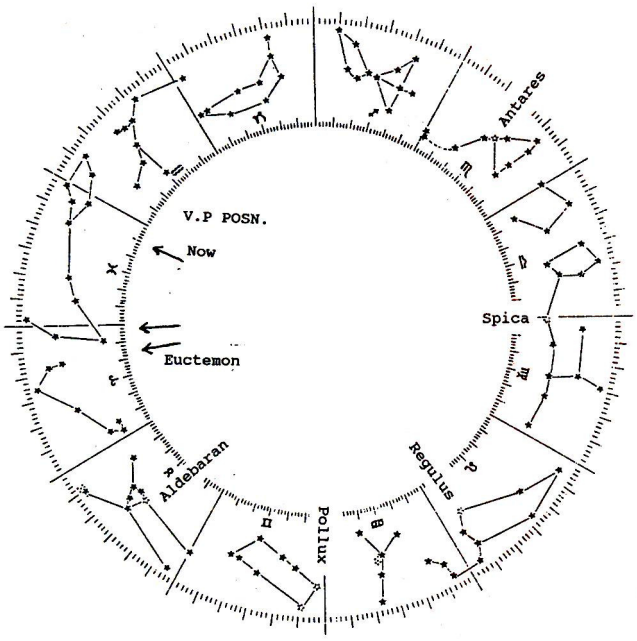
The Stellar Reference

In ancient lunar-planetary observational work, the star Pollux, though of first magnitude, was traditionally not regarded as having quite the same import as Aldebaran, Regulus, Spica and Antares, the four first-magnitude stars occultable by the Moon. Such prominent markers anchored the star-zodiac of antiquity. In the Babylonian division Spica lay somewhere near the end of the sign Virgo. Van der Waerden's conclusion that it was positioned at 29° Virgo, 'with a possible deviation of 1° to either side' gives a fair idea of the accuracy involved.[21]

In the 1940s, the Irish 'siderealist' astrologer Cyril Fagan averred that Aldebaran had originally been positioned at the centre of Taurus, i.e. at 15° longitude, as the prime reference point for the zodiac,[22] placing Spica at 29° of Virgo. A reconstruction of the star zodiac on this basis is shown in Figure 1. Several others have endorsed this view,[23] and in the mid-twentieth century a school of sidereal astrologers adopted this reference.[24]

After Fagan had reached this view, a detailed study by Peter Huber, a pupil of Neugebauer at Princeton, resolved the position of the Chaldean zodiac against the stars, by comparing given longitudes, in tablets dateable to the first and second centuries BC.[25] This is the only such study of a systematic nature, and his conclusion concurred within arc minutes with the position advocated by Fagan a few years earlier. In 1958 Huber published the result of his investigation, inferring an overall 'ayanamsa value,' of 4°28′ for 100 BC (ayanamsa is the Indian term, adopted by western astrologers, which defines the distance between the vernal point and 0^0 Aries in the sidereal zodiac). He derived that value using merely eleven star positions, expressing mean displacement of their stellar longitudes from those of the modern 'tropical' longitude (i.e. with respect to the Vernal Point), in that year. From his estimate of position, a date is derivable, of around 221 AD, plus or minus about fifty years, for when the

Figure 1: The Sidereal Zodiac (Source: Robert Powell), with names of some 1st magnitude stars, plus movement of Vernal Point from 5th century BC (Euctemon) and 2nd century AD (Ptolemy), to today at 25°.



two reference-systems, sidereal and tropical, coincided - a century after Ptolemy's *Tetrabiblos* was written.

The position of the brightest zodiac star, Aldebaran, the 'Bull's Eye', was given by Huber as 10°34′ of Taurus for his epoch of 100 BC,[26] which is 4°26′ short of the sign's mid-point, i.e. 15° in the Babylonian sign of the 'Bull of Heaven'. That difference is a mere few arc minutes from the mean displacement of the Chaldean zodiac which Huber ascertained for that epoch. This suggests that Aldebaran, at 15° Taurus or something close to it, was a prime reference.[27] Taking a different view, a recent British work considered that

> 'This [Chaldean] sidereal zodiac appears to have been fixed so that the longitude of the bright star β Gemini was 90°. Consequently, the

equinoxes and solstices occurred at about 10° of their respective signs in 500 BC'.[28]

It was not explained how such a view was derived, but it would put β Gemini (Pollux) at the sidereal Gemini/Cancer boundary (alluded to above as 90° in celestial longitude). This would differ by about a degree and a half from the earlier-discussed reference, and leave Spica at 30° of Virgo. No Chaldean tablets have been found which specify any rule for placing the sign divisions. Table 1 shows the longitudes of several stars which may be relevant, taking Aldebaran as 15°00' of the sidereal sign of Taurus for a reference.

There were thirty or so stars which appeared on texts after approximately 300 BC, being the standard Babylonian reference stars for defining lunar appulses (i.e. transits), and these included the above. These, sometimes called Normal stars, are mostly, but not always, in the same constellation as today, for example the 'rear foot of the lion' has been identified as the star beta Virgo.[29] However the above list of stars, four of which are near to boundaries, all appear as in the same constellation as today. Rotating the star-zodiac position to place Pollux at the sign boundary, i.e. at 30°, would put other stars into the adjacent sign. The stars in Table 1 give a position of the star zodiac within a degree or so.

Table 1: **Zodiacal longitudes 0-30° of some fixed stars, using a sidereal reference with Aldebaran at 15°00′ of Taurus. Corrections of a few arc minutes have been made for proper motion, for longitudes of 100 BC.**

Sidereal longitude 100 BC
Aldebaran (Taurus) 15°00′
Antares (Scorpion) 15°00′
Regulus (Lion) 05°12′
Spica (Virgin) 29°06′
Boundary Stars
Alhecka (Taurus) 00°02′ Gemini
Pollux (Gemini) $28^{0}48'$
Deneb (Capricorn) $28^{0}41'$

The Tropical Scheme

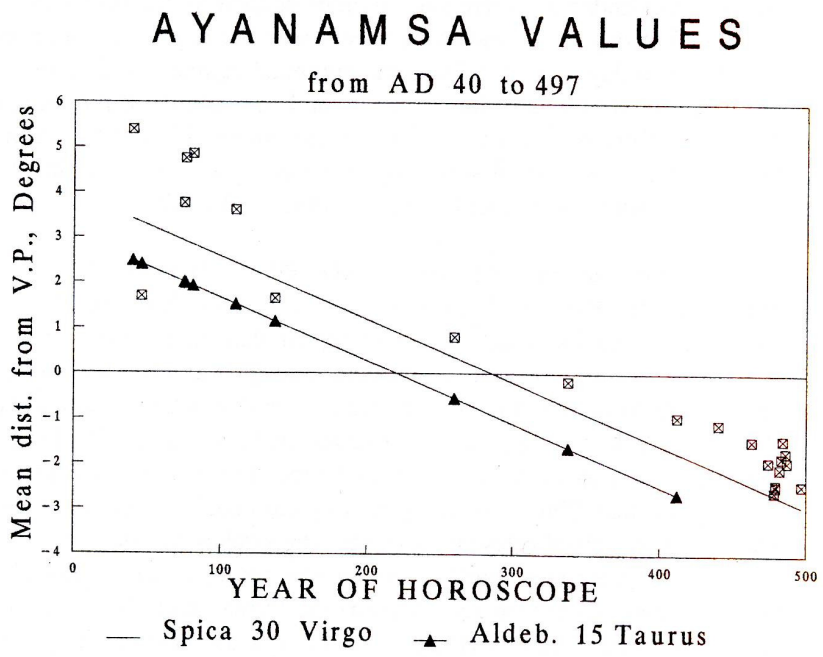
The tropical zodiac started life as a calendar, associated with the Greek astronomer Euktemon in the fifth century BC. He located the date of the summer solstice (from an observation at 431 BC), from which he constructed a calendar of twelve solar months defined by the equal-length signs: 'The first day of the month "Cancer" was the day of the summer solstice, the first day of "Libra" was the autumnal equinox, and so on'.[30] Other Greek mathematicians did not agree, and instead placed the Vernal Point 8° away from zero Aries.[31] The Greek astronomer Hipparchus in the second century BC was the first to prepare a catalogue of star longitudes, and he did so using the tropical zodiac, taking the Vernal Point as zero Aries.

Much later on, in the first century AD, Pliny's *Historia Naturalis* placed the Vernal Point at 8° of Aries, and a century later the Roman writer Vitruvius did likewise.[32] It would appear that, in the first century AD, these Romans were far from appreciating the phenomenon of precession, but were picturing an immovable Vernal Point, one valid for a much earlier epoch: eight degrees was fine for the fifth century BC, but by Pliny's time it was way out: his zodiac had slipped by five or six degrees. One could say that Pliny was using a 'tropical' zodiac, insofar as his Vernal Point had a fixed celestial longitude. Hipparchus had described the phenomenon of precession, but this notion was far from being generally accepted. He may have taken zero Aries as the Vernal point, but if so this had not made much headway (Hipparchus did not use celestial longitude for positions but instead an oblique or right ascension).

Greek Horoscopes

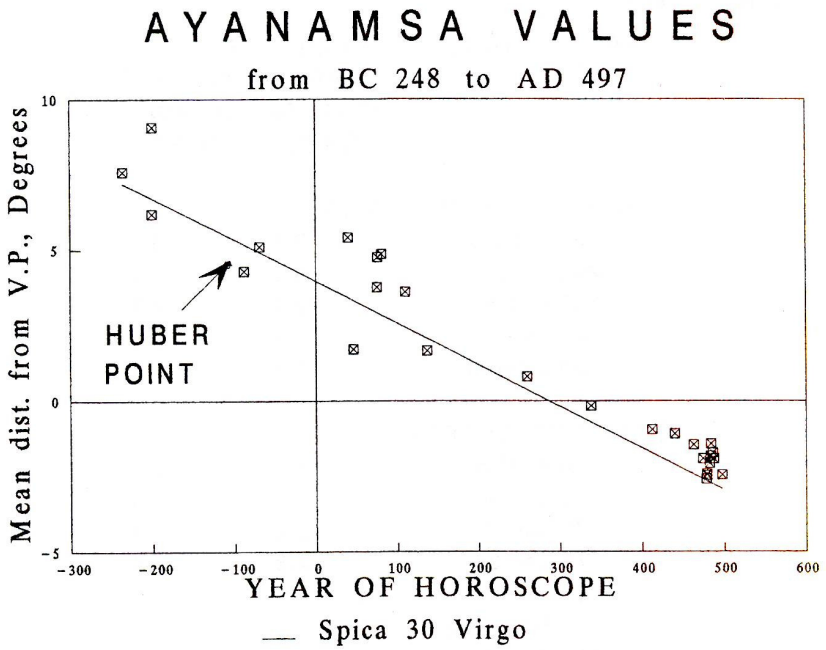
Otto Neugebauer's compilation, *Greek Horoscopes*, gives planetary longitudes of the earliest remaining Greek horoscopes, plus dates, spanning the first to the fifth centuries AD.[33] Neugebauer remarked that the charts in this volume were sidereal, i.e. they used a similar reference to the Babylonian zodiac.[34] It seemed to me that he was neither well able to show this nor to reach a conclusion concerning what zodiac framework was in use in these charts, since computing these things was harder in his day. About one-fifth of the charts in *Greek Horoscopes* book were cast for reliably known times and have zodiac longitudes specified for the planets (Table 2).[35] Using these, their ayanamsas were plotted against the year of their composition, to give a graph (Figure. 2).

Figure 2: Graph showing mean longitude differences {given in Greek Horoscopes - computed (tropical)}, each point being a mean of the planets, Sun & Moon excluding Mercury, per chart. Straight lines show theoretical values, taking Spica at 30° Virgo or Aldebaran at 15° Taurus.



Mercury positions were omitted, as these tend to be less reliable. For the other five planetary longitudes given (Sun, Moon, Venus, Mars, Jupiter and Saturn), a subtraction was made of the (tropical) longitude computed for that date and time, from that written on the horoscope. Any obviously erroneous values were omitted (taken as having difference values over twice the standard deviation of the group, for a chart). Then, the average difference value for the chart, i.e. the mean of the five difference values, was found. These difference values give an estimate of the ayanamsa. It can be seen that, in the group of charts for the first and second centuries AD, the longitude values used by the astrologers appear as greater than the corresponding tropical-zodiac positions, while, some centuries later, the last batch of charts in the fifth century gives a result the other way round.

Figure 3: As figure 2, but including five Babylonian horoscopes, giving ayanamsa-line for Spica at 30° Virgo, plus a 'Huber point' for Huber's mean ayanamsa value of 4°28' at 100 BC.



Two possible zodiac positions are shown as straight lines in Figure 2. The slope of each line corresponds to the rate of precession, viz. one degree per seventy-two years. The lower line corresponds to the star Aldebaran being placed at 15° of Taurus (and thus Spica at approximately 29° of the Virgin). This position does not well fit the data. The line above it shows the ayanamsa values that come from putting Spica at 30° of Virgo, i.e. on the Virgo/Libra boundary. This gives a better fit through the data. We may also compare the zodiac framework used by Babylonian horoscopes with the 'Greek' i.e. Hellenistic horoscopes surveyed above. A forthcoming survey has collated in total twenty-eight such Chaldean horoscope tablets.[36] Eight of these used degree longitudes to some extent, and five had sufficient to apply the above procedure for planetary longitude values. These five charts spanned 235 BC to 69 BC.

Table 2: Charts used in Figure 3, five Babylonian and 22 Hellenistic, showing differences in degrees {Historic - modern (tropical) computed} celestial longitudes, also scatter (standard deviation) of such values within charts in degrees.

YEAR	DATE	MEAN CHART AYANAMSA (DEGREES)	S.D. OF 6 PLANETS WITHIN CHART
BABYLONIAN CHARTS (B.C.)			
235	June 3	7.6	3.5
200	June 5	6.2	2.3
199	Oct 31	9.1	2.7
88	Jan 5	4.3	0.9
69	April 16	5.1	2.7
HELLENISTIC CHARTS			
40	April 5	5.4	1.6
46	Jan 3	1.7	4.8
75	July 19	3.8	3.9
76	Jan 24	4.8	0.9
81	March 31	4.9	2.1
110	March 15	3.6	3
137	Dec 4	1.7	2.9
260	Sept 29	0.8	2.9
338	Dec 24	−0.2	0.3
412	Feb 8	−1	1.4
440	Sept 29	−1.1	2.2
463	Apr 25	−1.5	0.7
474	Oct 1	−1.9	1
478	Aug 29	−2.6	0.8
479	July 14	−1.8	2.4
479	Oct 28	−1.4	1.4
482	Mar 21	−2.4	0.5
483	July 8	−2.5	0.6
484	July 18	−2.1	0.4
486	March 17	−1.7	1
487	Sept 5	−1.9	1
497	Oct 28	−2.4	0.6

Figure 3 shows the same 'Greek Horoscope' data as before, but with only one 'theoretical' line of zodiac position for the star Spica at 30° of the Virgin, and with a mean ayanamsa value computed by Huber for 100 BC inserted as a point, the 'Huber point', and the five Babylonian chart ayanamsa values have been added. This graph suggests that a single frame of reference for the sidereal zodiac was used by both Babylonian and Greek astrologers, enduring over eight centuries, before being forgotten in the Dark Ages. The data here presented does seem to support the above-quoted claim of Walker and Britton concerning ß Gemini (note 28), both for Greek (or, rather, Hellenistic) charts as well as Babylonian.

The charts dating from the first century have their planets 3-4° from the positions expected using a tropical system, i.e. an ayanamsa of 3-4°. There are a dozen or so such charts dated to the latter half of the fifth century, by which time the two wheels had crossed over and moved some two degrees apart.[37] These charts show that even in the centuries after Ptolemy, the astrologers writing in Greek continued to use a sidereal reference. The charts are mainly from Alexandria, indicating that even in Ptolemy's city the sidereal tradition endured.

Confirmation of this view comes from Egyptian astronomical tables of the first century AD that would have been consulted by astrologers.[38] They specify dates of entry of the planets into the signs of the zodiac. On average, Neugebauer found that about four degrees had to be added to their given longitudes to obtain modern (i.e. tropical) longitudes. As the graph showed, this is just what would be expected from the sidereal reference. Van der Waerden concluded 'the Egyptian mathematicians worked on the basis of a sidereal division of the ecliptic which almost coincided with the Babylonian division'.[39]

This thesis is supported by the recent work of Alexander Jones, as an explanation of how astronomical theory in Roman Egypt in the early centuries AD in large part evolved from the predictive methods known to us from Babylonian tablets of the last four centuries BC.[40] Jones concluded that '...it is now clear that practically the whole of Babylonian planetary theory was current knowledge in Roman Egypt, well after the publication of Ptolemy's writings and tables'.[41] This helps us to appreciate how Alexandrian astrologers of the period continued to use a Babylonian zodiacal framework.

These results, though admittedly from a small sample,[42] suggest that ancient astrology remained sidereal. Greeks who used the Tropical reference, such as Euctemon and Hipparchus, are remembered primarily

as astronomers,[43] concerned with such matters as calendars and star positions. There were various zodiac frameworks in antiquity, tropical and sidereal, but the evidence from surviving horoscopes clearly indicates that the latter type was used by astrologers, a fact glossed over by histories of astrology and astronomy.[44] These results are compatible with the view associated with Cyril Fagan, that it was not until several centuries after Ptolemy, around the 5th-6th centuries, that astrologers started to use a tropical zodiac.[45]

Ptolemy's View

Ptolemy utilised a tropical reference framework for the zodiac in his *Tetrabiblos*, i.e. for astrology, and is the first on record as having done this.[46] In his lifetime, the two wheels were only one degree apart. Using Hipparchus' star positions for his *Almagest*, he likewise advocated the same reference point as Hipparchus, viz. zero Aries. Thereby he unlinked the zodiac from its stellar framework and reconnected it to the four seasons. Janus-like, he could face both ways because he lived around the one period when the two wheels coincided. His zodiac was firmly constellational, and also firmly Sun-based. Did Ptolemy realise that the two systems were only together at one point in historical time - his life time? I doubt it.

However, although anchored to the seasons of the year by its celestial reference points, Ptolemy's zodiac remained sidereal in its astrological character. In the section in *Tetrabiblos* entitled 'Of the Nature of Signs, and their Effect upon the Weather' he alludes to the individual stars which comprise the Zodiac images: the effect of the sign Aries varied from one end to the other 'due to the special quality of the fixed stars'. The sign of Taurus had a 'leading portion, particularly near the Pleiades', together with 'its following portion near the Hyades'.[47] An earlier section, 'Of the Power of the Fixed Stars', describes how zodiacal stars operate, e.g. Antares in the 'body of Scorpio' is said to be Mars-like, though it is left unstated whether he is describing the twelve constellations, or signs. The same section describes the influence of various extra-zodiacal constellations on human beings.

Before Ptolemy, there were two traditions, of which that from Chaldea was astrological, while that in Greece was astronomical. These traditions fused in the melting-pot of Alexandria, where western astrology as we know it was born, after which the sidereal tradition faded away and a new

tropical tradition appeared, as if the astral images of the constellations had somehow become precipitated onto the ecliptic plane, to make a Sun-defined zodiac.

As the Vernal Point moved into Pisces, and the two systems coincided, the image of a fish came to be widely accepted as a symbol for the new Christian religion. The fish symbol first appeared in this context in Alexandria, at the beginning of the second century, and became 'current by the end of the second century'. This celestial transition was, it has recently been argued, a main reason for the early adoption of the Christian religion by the Egyptians, using the new religious symbol of a fish.[48] By the end of the third century, the Autumn Equinox had come into conjunction with the star Spica, making the Libra/Virgo boundary opposite the First Point of Aries appear as the start of the zodiac.[49]

The astrologers of the Muslim world took Ptolemy's two books as their chief link with past tradition, and so their zodiac was *tropical*, as Fagan argued.[50] Ptolemy's fixing of the start of the zodiac at the equinoctial point, a position in space defined by a point in time of the year's cycle, became henceforth the only zodiac they knew about. Thus the star zodiac vanished from the West while Indian astrologers followed the earlier tradition: 'In its original form the zodiac in India was probably the Zodiac used by Greek astrologers, which, owing to the spread of astrology, became transmitted to India in the 2nd century A.D'.[51] Indian astrologers do not admit that their zodiac was so derived, believing in the immemorial antiquity of Hindu culture. However, they now use a star-based zodiac (the 'Lahiri' ayanamsa) with Spica at 30° of Virgo, which would appear to be the very same as was used throughout the Hellenistic world.[52]

It has here been argued that astrologers of the ancient world measured longitudes using a sidereal reference. We found no evidence that they used a tropical reference for their horoscopes. A coherent sidereal framework existed over at least eight centuries, though one is not sure exactly how this was fixed, if indeed there was one such definition. Respect for the Chaldeans, who invented horoscopic astrology, was such that the tradition endured, so long as this origin was remembered.

References

1. Otto Neugebauer, *A History of Ancient Mathematical Astronomy*, II, 1975, pp.593-4.

2. Rupert Gleadow, *The Origin of the Zodiac* 1968 p.28; W.M. O'Neill, *Early Astronomy* (Sidney U.P.1986), p.26. John Britton and Christopher Walker, 'Astronomy and Astrology in Mesopotamia' in *Astronomy Before the Telescope*, Ed. Christopher Walker (London 1996), Marie Delclos, *Astrologie Racines Secretes et Sacres* (Paris 1994), Ch. 17. A source problem is the absence of statements from Hellenistic astrologers themselves as to whether their zodiac was genuinely sidereal, i.e., tied to the stars, or fixed to a starting point which may not have been the vernal point, such as 8^0 or 10^0 and was therefore in effect tropical. This problem is discussed by Robert Hand in his introduction to Vettius Valens, *The Anthology*, Book 1, Golden Hind Press, PO Box 002, Berkeley Springs, WV, 1993, p iii. The tale of the sidereal zodiac's rediscovery has been well described in *From The Omens of Babylon* by Michael Baigent (London, 1994), but without comment either on the zodiac signs or the position of zodiac divisions in relation to the stars.

3. Britton and Walker, op. cit. (2), p.49: '17 sometimes interpreted as 18'; Gleadow op. cit., p.163, 'The Eighteen Signs'; Jim Tester, *A History of Western Astrology*, 1987, p.14; F.Rochberg-Halton, 'New Evidence for the History of Astrology', *Journal of Near-Eastern Studies*, 43,1984, pp.115-127, 122.

4. Christopher Walker, 'A Sketch of the Development of Mesopotamian Astrology and Horoscopes', *Clio and Urania Confer*, Ed Kitson,1989, pp.7-14, 9.

5. B.L.van der Waerden, *Science Awakening II, The Birth of Astronomy* (Leyden and New York 1974), p.80.

6. O'Neil, op. cit, p.17 (diagram of early Taurus constellation).

7. A.E Thierens, *Astrology in Mesopotamian Culture* (Leiden 1935), p 51, translates this as 'agricultural labourer'.

8. Owen Gingerich, 'Astronomical Scrapbook: The Origin of the Zodiac' *Sky & Telescope* 1984, 67, 218-20, in Gingerich, *The Great Copernicus Chase* 1992 Ch.2.

9. Van der Waerden, op. cit., p.72.

10. Alex Gurshtein, 'The Real Zodiac', *Sky & Telescope* 1995, p.31-3, 32.

11. Robert Eisler, *The Royal Art of Astrology*, 1946, pp.97,99; Van der Waerden, op. cit., p.81.

12. Van der Waerden, op. cit., p.123. The Denderah zodiac may not have been a faithful depiction of constellation images, e.g. it depicted the whole Bull-of-Heaven, whereas only the front portion existed as a constellation: thus, the rear portion of Taurus depicted at Denderah may not ever have 'existed' i.e. have been perceived in the sky.

13. George Sarton, *A History of Science* I, Harvard University Press, 1953, p.72; John North*, The Fontana History of Astronomy and Cosmology*, 1994, p.21.

14. Walker, op. cit., p.11.

15. Britton and Walker op. cit., p.49.

16. Hugh Thurston, *Ancient Astronomy* (New York 1994), p.71: 'No Babylonian tablets deal directly with the sun. We have to deduce the Babylonian theory of the sun's motion from details on the tablets dealing with the moon'. Thurston cites a Full-Moon tablet from the second century BC, with twelve months starting with Nisan in the spring, and twelve signs of the corresponding Full moon, starting with their equivalent of Scorpio.

17. Abraham Sachs, 'A Late Babylonian Star Catalogue' *Journal of Cuneiform Studies* 1952, 6, pp.146-50 gave star longitudes in degrees over Virgo and Leo (e.g. Spica 28° Virgo), dated to the fourth century.

18. North, op. cit., p.40.

19. The Metonic cycle originated 'at best in the beginning of the 5th century, or perhaps even later'. Neugebauer, *Journal of Cuneiform Studies*, 1940, 2, p.220.

20. Liba Chaia Taub, *Ptolemy's Universe*, Illinois, 1993, p.139.

21. B.L. Van der Waerden, 'History of the Zodiac', *Archiv fur Orientforschung*, 1953, 16, pp.216-230, p.222.

22. Cyril Fagan, *Zodiacs Old and New*, 1951, p.18.

23. Rupert Gleadow, op. cit.,p.28; Robert Powell and Peter Treadgold, *The Sidereal Zodiac,* 1978, 1985, AFA; R .Powell, *The Zodiac: A Historical Survey* ACS San Diego (no date) 16 pp; Marie Delclos, *Astrologie Racine,* cites the primal markers as having been Aldebaran and Antares as 15° 'exactement' of Scorpio/Taurus, Regulus as 5° Leo, Spica at 29°, also Formalhaut and the Pleiades (Ch. 17).

24. Neil Michelson's *The American Sidereal Ephemeris 1976-2000,* Astro Computing Services, CA, 1980, gave Aldebaran as 15°03' Taurus and Antares as 15°01' of Scorpio.

25. Peter Huber, 'Ueber den Nullpunkt der Babylonischen Ekliptic' *Centaurus* 1958, 5, pp.192-208.

26. Huber, op. cit., p.205.

27. The two first-magnitude zodiacal stars Antares and Aldebaran were 180° apart to within a single arcminute over the period 300 BC to 1200 AD: Dennis Rawlins has computed that although these two may 'never be seen simultaneously in the Mediterranean area', on some days each year they could be seen together from below the Tropic of Capricorn, *Dio*, April 1992 p.15 (an independent history of astronomy journal, Ed. Rawlins, US).

28. Britton and Walker, op. cit., p.49.

29. A.Sachs in D.G.Kendall et. al. Ed., *The Place of Astronomy in the Ancient World*, OUP 1974, p.46. Sachs gave both the modern classification and the old name, e.g. gir *ar sa* A (rear foot of the lion) and beta Virgo (translation by Christopher Walker).

30. Van der Waerden, op.cit. (note 5) p.289.

31. This ayanamsa is associated with Eudoxus and Meton in the 4th century: Van der Waerden, *Science Awakening*, p.290, 'History of the Zodiac', p.228.

32. Vitruvius, *De Architectura* Ch.9,3; Pliny *Historia Naturalis* XVIII Ch.59, p.221; Otto Neugebauer, *A History of Ancient Mathematical Astronomy* II 1975 p.594; Gleadow called this the Hellenistic Zodiac, claiming that it was used 'by Manetho and the Michigan Papyrus', and that it had been 'correct about 373 B.C' op. cit.(note 2), p.75.

33. Neugebauer and van Hoesen, *Greek Horoscopes* (Philadelphia 1959, 1987), p.594: there existed a 5° deviation between modern (i.e. tropical) longitudes and

longitudes given in Greek horoscopes. In other words the astrological literature of the hellenistic-Roman period still preserves the norm of Babylonian astronomy'. (N.B., the authors of the horoscopes in this collection were probably non-Greek Hellenised Syrians or Egyptians, and in some respects it could be misleading to describe such horoscopes as 'Greek'.)

34. Neugebauer, *Greek Horoscopes*, p.172: 'Longitudes in Vettius Valens are sidereal longitudes whereas the later authors operate with tropical longitudes, obviously following the norm adopted by Ptolemy and Theon'.

35. Many of the charts in *Greek Horoscopes* are from Vettius Valens, however only two of the 22 charts here used were by him, as the rest of his collection did not give degree longitudes.

36. Francesca Rochberg, 'Babylonian Horoscopy: The Texts and their Relations', *Dibner Institute* Proceedings, N.Swerdlow, Ed., U. Chicago Press, forthcoming, pp.1-27 (I am grateful for permission to cite horoscopes from this text); Francesca Rochberg-Halton, 'Babylonian Horoscopes and their Sources', *Orientalia*, Vol 58 - Fasc 1 - 1989.

37. In Figure 2, seven charts shown from AD 40-140 have a mean ayanamsa of 3.7±1.4°, while for a group of eleven charts AD 460-500 the equivalent was 2.0±0.4°.

38. Van der Waerden, op. cit. (note 5), p.308; Neugebauer & Parker, *Egyptian Astronomical Texts*, 1969.

39. Ibid., p.309.

40. Alexander Jones, 'Studies in the Astronomy of the Roman Period', *Centaurus* 1997, 39 1-36, 2.

41. Alexander Jones, 'Babylonian Astronomy and its Legacy', *Bulletin of the Canadian Society for Mesopotamian Studies*, 1997, 32, pp. 11-16, 16.

42. Donata Baccani, *Oroscopi Greci: Documentazione Papirologica* (Ricerca papirologica 1; Sicania, Messina 1992), contains a further collection of Egyptian papyrus horoscopes. A further seventy charts are due to be published by Alexander Jones (Toronto) in his forthcoming *Astronomical papyri from Oxyrhynchus.*

43. It has been claimed that Hipparchus had a 'pivotal role' in 'introducing Babylonian Astronomy to the Greeks', as 'an advocate of astrology': G.J.Toomer, 'Hipparchus and Babylonian Astronomy', *A Scientific Humanist:*

studies in memory of Abraham Sachs Ed. Leichty & Ellis, 1988, p.357. Toomer has not substantiated this claim.

44. *Ancient Astrology* by Tamsyn Barton (London, 1994) defined the zodiac by reference to the Vernal Point as zero Aries (p.88), thereby conveying the erroneous view that ancient astrology was tropical. Two erudite books have of late appeared both entitled *Early Astronomy*, neither giving any hint to their readers that there once existed a sidereal zodiac. O'Neill, *Early Astronomy*, p 25-6 (see note 2) gives a fine coverage of Babylonian astronomy, though without alluding to their reference for measuring celestial longitude. Thurston, *Early Astronomy*, p 68 (see note 16), does ask the question, 'Where precisely on the ecliptic were the signs placed?' but answers in tropical terms, with the solstices fixed at some degree of their signs, either 8° or 10°. Alex Gurshtein, op. cit. (9); 'On the Origin of the zodiacal Constellations' *Vistas in Astronomy,* 1993, 36, pp. 171-190, jumps straight from the twelve constellations into 'the traditional zodiac' established by the fifth century BC, i.e. the tropical, as does Owen Gingerich in 'The Origin of the Zodiac', *Sky & Telescope* 67, 218-20, in Gingerich, *The Great Copernicus Chase*, 1992, Ch.2.

45. Fagan, op. cit., p.29.

46. John North, *The Fontana History of Astronomy and Cosmology*, 1994, writes that Ptolemy 'introduced' the tropical zodiac, p.67.

47. Claudius Ptolemy, *Tetrabiblos*, Loeb Classical Library, 1940, pp.201-203.

48. Martin Bernal, *Black Athena* (London 1991), p.131; *New Catholic Encyclopaedia* 1967, section on Pisces.

49. Duncan Mac Naughton, *A Scheme of Egyptian Chronology*, London 1932, p 173: 'The zodiac was measured from Spica'.

50. Nicholas Campion, *An Introduction to the History of Astrology*, 1989, p.29: first Arabic horoscope AD 531; Fagan, ref. (note 22), p.29.

51. Powell and Treadgold, op.cit.(note 23), p.17.

52. Spica will be at 23°48' of Libra (tropical) in AD 2000. This will therefore be the 'ayanamsa' of the Indian 'Lahiri' system for that epoch.