Geometry of the Mesopotamian "ecliptic"

G.E. Kurtik[1]
[1]Institute for the History of Science and Technology, Russian Academy of Sciences,
Baltiyskaya ul. 14, 125315, Moscow, Russia
kurtik@bk.ru

(Submitted on 29.05.2017. Accepted on 28.08.2017)

Abstract. The article deals with the history of ecliptic as an element of the mathematical astronomy in Ancient Mesopotamia. It contains data from the cuneiform sources of the 2nd - 1st millennia BC and from the modern studies shedding light on the following three questions: 1) the idea of the celestial sphere in Mesopotamian astronomy; 2) the geometric representations associated with the ecliptic; 3) the positions of the ecliptic relative to the fixed stars and to the Sun. It is shown that although we do not have solid evidences, however, there are serious reasons to believe that in the Seleucid period in the mathematical astronomy and astrology the ecliptic was conceived geometrically as a circle divided into 12 equal parts. It is also shown that in this period the ecliptic was not yet identified with the projection of annual path of the Sun to the celestial sphere.

Key words: Mesopotamian astronomy, zodiac, ecliptic

In modern astronomy, the ecliptic is defined as the great circle of celestial sphere, along which the visible annual motion of the Sun takes place. Mesopotamian representations of the ecliptic, however, did not fully correspond to modern concepts. The difference concerned two points: firstly, the Mesopotamian "ecliptic" was not associated with the Sun; secondly, it is not clear what form the ecliptic had and how it was spatially conceived. The word "ecliptic" in the text of article for this reason we write in brackets.

In this article we will analyze sources shedding light on the geometric representations associated with the "ecliptic", trying to show that in Mesopotamian astronomy the "ecliptic" was circular.

First of all, it must be emphasized that the concept of the celestial sphere has never, apparently, been known to Mesopotamian astronomers. Cuneiform texts do not contain any explicit instructions confirming the existence of such representations. There is, however, a number of indirect evidences indicating that the Mesopotamian astronomers, if they did not clearly formulate the concept of the celestial sphere, then, at least, came close to the idea of the sphericity of the sky.

O. Neugebauer wrote about this:

"That the Babylonian astronomers assumed a spherical sky, or, to put it more cautiously, a spherical surface of reference, seems undeniable in view of the use of orthogonal ecliptic coordinates. However, we do not know how far this concept was considered to be a description of physical reality. We are also not sure whether these ecliptic coordinates were ever used much beyond the zone of the ecliptic and the Normal Stars." (Neugebauer 1975, 577).

In the literature, in this connection, it is often suggested that the Babylonian zodiac was in the form of a circle or circular belt, as Mesopotamian astronomers thought it (Hunger, Pingree 1999, 18; Koch-Westenholz 1995, 168; Huxley 1997; Brown 2000, 115; Van der Waerden 1974, 83; Kurtik 1999, 72-73). A characteristic statement: "It is apparent from the circular astrolabes and from what may be a circular zodiac from Sippar that the

ecliptic and the celestial equator were regarded as circles." (Brown 2000, 115). To what extent are such assertions justified?

From mythological and cosmological texts it is known that the concept of a circle from antiquity was connected in Mesopotamia to heaven and earth. This is indicated by the following Akkadian terms: *kippat šamê* "circle of the sky", *kippat burūmē* "circle of the (night) sky", *kippat šamê u erṣeti* (sum. an.ki.nigin.na) "circle of heaven and earth". The word *kippatu* means in Akkadian "circle, circumference, ring, hoop". Undoubtedly, some part of the sky in the eyes of the inhabitants of Mesopotamia seemed circular (Horowitz 1998, 226-227, 260, 264).

A closer examination, however, shows that such definitions were apparently related only to the horizon line, and not to the whole sky. On the so-called "Babylonian map of the world" real earth regions are separated from the mythological regions by two concentric circles (Horowitz 1988; 1998, 20-42). The sky as a whole in Mesopotamia was represented in the form of a dome, the central part of which was raised to a high altitude, and the edges closed on the horizon with flat ground in a circle (Horowitz 1998, 256, note 14; Kurtik 1999, 64). The earliest testimony known to us is the pictographic image of the sign ge_6 "to be dark, night", a night sky on it is depicted as a dome (Labat 1976, no. 427; Green, Nissen 1987, no. 213). In one religious hymn the shape of the sky is defined as "bowl-shaped" (Rochberg 2004, 127; 2005, 328). Such cosmological ideas excluded the concept of the celestial sphere. However, as F. Rochberg rightly notes, mythological texts containing archaic ideas of round flat land and bowl-like sky were very far from mathematical astronomy, where the notion of "ecliptic" was used [ibid.].

The circle in the description of the starry sky is found in a number of astronomical and astrological texts. The earliest example refers to the second half of the 2nd millennium BC. These are the so-called "circular Astrolabes" (which had the form of disks), on which the stars were located on three concentric belts. They were divided from the center into 12 sectors of 30° each, which corresponded to the 12 months of the Babylonian calendar. For the fragments and reconstructions of "circular Astrolabes" see (Horowitz 1998, 156; 2014, 1, Fig. 1, 122-124, Plates XX, XXIII, Fig. 21, 25).

Another example is the so-called "Planisphere" (dated by the Neo-Assyrian period) - a disk divided into 8 sectors, inside of which are placed the schematic images of constellations and their names. For the reconstruction and research of "Planisphere" see (Koch 1989, 56-61).

Of particular interest is the so-called "Sippar Planisphere", dating from the Neo-Babylonian period. It depicts a circle, divided, like astrolabes, into 12 sectors, each containing names and schematic images of two or three constellations from the list of so-called *ziqpu*-stars. *Ziqpu*-stars are a sequence of stars culminating in the latitude of Babylon and Assyria in the central part of the sky. These stars formed a closed belt in the sky and were used to fix time at night (Horowitz, al-Rawi 2001; Kurtik 2007, z11). The "Sippar Planisphere" testifies: Mesopotamian astronomers considered the sequence of *ziqpu*-stars geometrically as a circle in space.

The confirmation is found in the other lists of *ziqpu*-stars. One of them contains the statement: "A total(?) of 12 DANNA of the circle (of those stars that) culminate (*kip-pat zi-iq-pi*)" (Horowitz 1994, 92: 20). Here DANNA = *bēru* = 30° is the angular unit. It follows from this text that the sequence of *ziqpu*-stars was thought of as a circle (*kippatu*) which is 360°.

Thus, we can conclude that the elements of geometric modeling have been used by Mesopotamian astronomers to describe the positions and movement of stars. Among the surviving evidence, however, there is no data directly related to the zodiac.

The exception is, perhaps, a round diagram in the Seleucid astrological text TCL 6 13. It depicts a circle divided into 12 equal parts by four regular inscribed triangles, so that two adjacent points on the circle, marked by their vertices, are spaced apart from each other at 30°. Each point is associated with the name of one of the 12 months of the Babylonian calendar, as well as the name of one of the five planets. The names of the months on the circle follow strictly in counter-clockwise order (Thureau-Dangin 1922, Pl. XXVI, 13; Rochberg-Halton 1987, 226) (see Fig. 1).

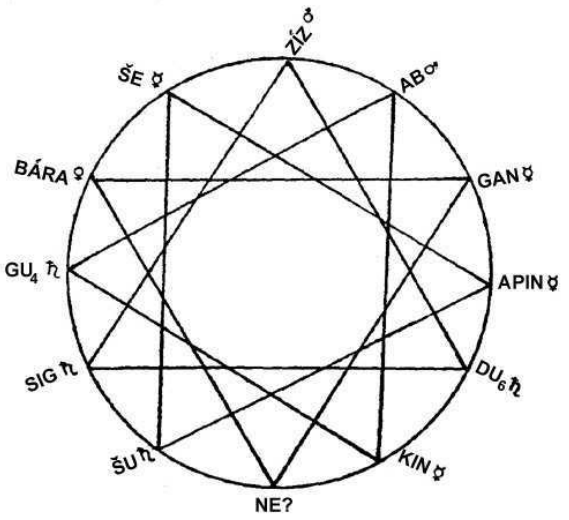

Fig. 1. A drawing of the circle with the inscribed regular triangles and the names of the months (= the signs of the zodiac) and the planets from TCL 6 13, given in (Rochberg-Halton 1987, 226, Fig. 1)

The astronomical and astrological meaning of this diagram does not lend itself to unambiguous interpretation. One possible interpretation is connected to the trigonal aspect (trine), known from Greek astrology. The diagram represents, probably, the early Mesopotamian version of this idea. But if it is so, then we must assume that it depicts not the calendar but the circle of "ecliptic" on which the names of months denote the signs of zodiac, as is customary in a number of other texts of the same period, see,

for example, (Brack-Bernsen, Hunger 1999, 288; Brack-Bernsen 2003, 25; Kurtik 2013, 154-155)[1].

Thus, although we do not have the undeniable evidence, there are serious reasons to believe that in the Seleucid period in Mesopotamian mathematical astronomy and astrology, the zodiac was conceived geometrically as a circle divided into 12 equal parts.

It is well known that the Mesopotamian "ecliptic" was fixed sidereally. In a paper of 1958 P. Huber showed that for some zodiacal signs the dates of crossing from one sign to another, predicted in "Almanacs"[2], always coincide with the predicted dates of the planetary conjunctions for the same year with one of the so-called *Normal Stars*[3]. This is possible only if the "ecliptic" is fixed relative to the fixed stars.

It was also found that the dates of the planet entrances in Gemini, Cancer and Aquarius in "Almanacs" always coincide with the dates when the planet was observed "above" or "below" of the *Normal Stars* ζ Tau, β Gem and δ Cap respectively. Obviously, these stars fixed the boundaries of the corresponding signs of the zodiac (Huber 1958; Jones 2004, 500). There are also two catalogues of the *Normal Stars*, which for a number of stars give positions in degrees within the zodiacal signs (Roughton, Steele, Walker 2004).

P. Huber also established that a zero point of the Mesopotamian "ecliptic", that is, a point with a longitude 0° Aries, was located near the star of η Psc in epoch of -100 (Huber 1958, 204-205). This result was recently confirmed in the study (Steele, Gray 2007).

The position of the Mesopotamian "ecliptic" on the celestial sphere is not exactly defined. It is known, however, that planet motions, including the Sun, were described using the notion of the "path" (KASKAL = *harrānu*, lit. "way, road")[4], a closed belt that had a width. The width of the "path" was determined in the different ways for the different luminaries. For the Moon, for example, it was 12°, for the Sun - 7 "fingers" ($7 \times 5' = 35'$) (Steele 2007, 311, 315). Thus, it was assumed that the Sun moves not only in longitude, but can also change its latitude like all the planets. Obviously,

---

[1] In the cuneiform texts the following ratios between the months and the signs of the zodiac were accepted: *nisannu* ($BARA_2$) - Aries, *ayaru* (GU_4) - Taurus, *simanu* (SIG_4) - Gemini, *duuzu* (ŠU) - Cancer, *abu* (NE) - Lion, *ululu* (KIN) - Virgo, *tashritu* (DU_6) - Libra, *arahsamnu* (APIN) - Scorpio, *kislimu* (GAN) - Sagittarius, *tebetu* (AB) - Capricorn, *shabatu* (ZIZ_2) - Aquarius, *addaru* (ŠE) - Pisces (the Akkadian names of the months are given here in a simplified form). The relation between the months and the planets adopted in the diagram under consideration remain unclear so far.

[2] The "Almanacs" - the astronomical cuneiform texts (the earliest date to the beginning of the 3rd century BC) included computed data characterizing the motion of the Moon and the planets for one year. For an analysis of this category of the texts see (Hunger, Pingree 1999, 159-167).

[3] The *Normal Stars* - about 40 stars, distinguished in the zodiacal belt, relative to which in the so-called "Diaries" the positions of the Moon and the planets were regularly fixed. Mesopotamian name: mul.šid.meš, lit. "Stars (for) counting". For a list of the *Normal Stars* see, for example, (Hunger, Pingree 1999, 148-149; Kurtik 2007, m39; Roughton, Steele, Walker 2004).

[4] The Akkadian word *mālaku*, "path", "orbit" (?) was also used.

during this period the "ecliptic" was not yet identified with the projection of annual path of the Sun to the celestial sphere.

References

Brack-Bernsen L. 2003, *Centaurus*, 45, 16-31.
Brack-Bernsen L., Hunger H. 1999, *Centaurus*. 41, 280-292.
Brown D. 2000, *Cambridge Archaeological Journal*, 10, 103-122.
Green M.W., Nissen H.J. 1987, *Zeichenliste der Archaischen Texte aus Uruk*. Berlin: Gebr. Mann Verlag.
Horowitz W. 1988, *Iraq*, 50, 147-165.
Horowitz W. 1994, *Journal of Cuneiform Studies*, 46, 89-98.
Horowitz W. 1998, *Mesopotamian Cosmic Geography*. Winona Lake.
Horowitz W., al-Rawi F.N.H. 2001, *Iraq*, LXIII, 171-181.
Horowitz W. 2014, *The three stars each: the astrolabes and related texts*. Vienne: Institut für Orientalistik der Universität Wien.
Huber P. 1958, *Centaurus*. 5, 192-208.
Hunger H., Pingree D. 1999, *Astral Sciences in Mesopotamia*. Leiden-Boston-Köln.
Huxley M. 1997, *Journal of the Royal Asiatic Society*. Ser. 3, Vol. 7, 189-198.
Jones A. 2004, *Archive for History of Exact Sciences*. 2004, 58, 475-536.
Koch J. 1989, *Neue Untersuchungen zur Topographie des babylonischen Fixsternhimmels*. Wiesbaden.
Koch-Westenholz U. 1995, *Mesopotamian Astrology*. Copenhagen: Museum Tusculanum Press.
Kurtik G.E. 1999, *Issledovaniya po istorii phiziki i mechaniki (Studies for the history of physics and mechanics)* (1995-1997). M .: Nauka, 60-75.
Kurtik G.E. 2007, *Zvezdnoe nebo drevney Mesopotamii (The Star Heaven of Ancient Mesopotamia)*. St.-Petersburg: Aletheia.
Kurtik G.E. 2013, *Istoriko-astronomicheskie issledovania*, 37, 145-167.
Labat R. 1976, *Manuel d'épigraphie akkadienne*. Paris.
Neugebauer O. 1975, *A History of Ancient Mathematical Astronomy*. Berlin-Heidelberg-N.Y.: Springer-Verlag.
Rochberg F. 2004, *The Heavenly Writing: Divination, Horoscopy and Astronomy in Mesopotamian Culture*. Cambridge and N.Y.: Cambridge University Press.
Rochberg F. 2005, *A Companion to the Ancient Near East*. Ed. by D. Snell. Oxford: Blackwell Publishing, 316-329.
Rochberg-Halton F. 1987, *Zeitschrift für Assyriologie*, 77, 207-228.
Roughton N.A., Steele J.M., Walker C.B.F. 2004, *Archive for History of Exact Sciences*. 2004, 58, 537-572.
Steele J.M. 2007, *Annals of Science*, Vol. 64, No. 3, 293-325.
Steele J.M., Gray G.M.K. 2007, *JHA*, XXXVIII, 443-458.
Thureau-Dangin F. 1922, *Tablettes d'Uruk*. Paris.
Van der Waerden B.L. 1974, *Science Awakening II. The Birth of Astronomy*. N.Y.- Leiden.