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ASTRONOMY AT MESOPOTAMIAN REGION (3000BC-1400AC)

HAMID M.K. AL-NAIMIY
College of Arts and Sciences, University of Sharjah, Sharjah, UAE

Abstract. I - The Babylonian (Mesopotamian BC) astronomy achievements have been divided into three classes according to the type of activity and period, such as:

1. The early schematic Babylonian astronomy for the period (3000 - 750 BC), including :

- Observing the periodical and astronomical phenomena such as Eclipses.

- Simple schematic and linear equations for celestial phenomena.

- Astrolabe texts and the helical stars rising along the eastern horizon.

- The calculation of the duration of days and nights throughout the year, produces a function known as the linear ZIG-ZAG function.

2. The Non-Mathematical astronomy (depends on watching the sky and the omens) during the period (750 - 350 BC), including: Astronomical Diaries, Almanacs and the Goal year text.

3. The Mathematical astronomy from the period (350 - 50 BC), including: The astronomical Ephemeris or tables of lunar, planets and stars phenomena, with other important achievements computed at a regular interval, and astronomical observatories. Besides, the oldest mathematical linear function appeared from the Babylonian astronomical measurements from uniform equations of the relation between lunar and synodic year. At the same time we should mention the discoveries of the 12 zodiacal constellations, the circular astrolabes, the Almanacs, the Ephemeris and other astronomical issues, including, the tables of observation or prediction of the Lunar and Solar Eclipses.

II - The paper contains as well the most important achievements of the Arab and Muslim Astronomers in Astronomy in the same region during the period 900 - 1400AC.

1. Introduction

It is due to the clear sky that is free from any lights and Industrial pollution that the Mesopotamians became the pioneers in Astronomy. Also the beauty of their lands and the fertility and the availability of water on them, accelerated the emergence of the first human settlement especially on the sediment level land from the southern of Iraq (down the Euphrates), the ancient Iraq, or the land between the rivers Tigris and Euphrates.

In addition, the shortage of their lands to some raw materials like woods, valuable stones and metals made them import these materials from the neighboring countries, therefore, they became warriors, tradesmen, farmers, and they prepared the armies to protect the transport ways and they went on the deserts and seas. So, they resorted to the use of the stars to know the routes during the nights, because without the stars the armies would loss their ways and their caravans would be in the great danger of the deserts and the seas. By the year 3000 BC, the Mesopotamian culture had developed an irrigation system, building methods using clay bricks rather than wood or mud, and a system of writing. For Example: (Ziggurats: the Mesopotamians built of clay bricks on the flat flood plain of the Tigris and Euphrates rivers), (Ahmad, 2003).

They also resorted to the use of stars in order to set the calendars determining the times of sowing and harvest, flood, and the feasts. They also used the phases of the moon, zodiac of the sun and the positions of the planets to predict the states of the weather and to assign the dimensions of the countries and the calculation of the crescent appearance and other matters that are connected with their daily life (Al-Naimiy, 1990).

Astronomy had been a very interesting subject that stirred the interests of people in the former centuries. As such various names have been given to this science. Some of these are really the science of stars, the science of the shape, the science of the universes, the science of astrology, the science of creating stars and astronomy, these are the commonest and the most famous names in our legacy. But the name astrology is the strongest due to its deep roots in our culture. It dates back in its origin to the Babylonian work "Pulukku" (Al-Naimiy, 1990), where it means the monitoring of stars, and if we look a little bit closer in the derivation of term "astronomy" and "astrology", we would find that they originate from the Latin term "Astro", which means star and refers to the planets and the universes in general. This Latin word is taken from the name of the Babylonian goddess "Ishtar" that was shifted in the Hebrew language into "Aster" then into "Astr". The evidence is that there were goddess for justice in Greece called "Astraea" which is derived from the Babylonian "Ishtar" as well. It is known that the Babylonian "Ishtar" and before it the samurai "Inana" represents planet Venus, the goddess that was very popular at that time as morning star, evening star and it was a symbol for beauty and loyalty (Rashid, 1987). It was also believed that its emergence and disappearance impact the life of the Man on Earth. While the Greeks term was "Astronomia" which means in Arabic the science of stars and its literal translation "Astr" means star while "Nomia" means science. In fact, the beginning of the predictable experimental astronomy started in Mesopotamia throughout their relation with the agricultural purposes that are connected with the rain. This started approximately 3000 years BC when Astrology was activated with the growth of magic as well. This paved the way to evolution of clear religion later on, and this goes in line with the idea that astronomy or astrology was started basically to establish an earthly and celestial religion (Ahmad, 2003). Therefore, in this research we will not come across the Babylonian astronomy before the period 3000 years BC, while we are going to look for the Babylonian astronomical achievements during the period 3000 BC till 50 A.D. This was the beginning of real astronomy according to our estimation that involves the Sumerian, Caledonian, and the Babylonian Astronomy. We are going however to call it generally the Babylonian Astronomy in order to agree with the common European names nowadays. We will try to follow a division to the achievable and the chronological order.

What I am after in this regard is really the documented astronomy in terms of the observations, predictions, and the calculations, in addition to the practices of the celestial anticipation in the ancient Mesopotamia with the intention of stopping by the basic differences that discriminate these practices with their alternatives in the Greece countries during the same period or after on one hand, and what is available right now on the other hand. Although there was a big deal of information still unknown so far and so many questions need to be set. In this paper we are speaking about the ancient Iraq or the land between Tigris and Euphrates. In this area we find that the evolution of the precise sciences such as Mathematics and astronomy, were developed alone without other sciences in the sense that in some civilizations, for instance, astronomy had never reached the status of a scientific subject due to the primitivism of the mathematical tools. Therefore, this science had stayed in the preliminary informative and the planning level; also it hasn't any influence on the other cultures. While in Mesopotamia astronomy, on the contrary from, had been accorded a dignified status in accuracy and its impact had been stretched to the futuristic developments in the Greek and Indian sciences and later in the Islamic ones. The Babylonian astronomy used to have a very influential impact on the Greek world due to the availability of the great excess of amount for understanding the celestial phenomena. In spite of the co-occurrence of the last two periods from the Caledonian astronomy with the Greek astronomy, the Caledonian one was the first source for the celestial information and tables. The Caledonian excellence in astronomy was very evident even in its arousing from the first philosophical Greek questions. On this basis, we have been able to by the help of Allah divide the Babylonian astronomical and intellectual achievements during the period from 2500 BC to 50 BC into three divisions according to a chronological order that fit with the astronomical achievement and the text at the hand. These divisions are as follow:

1. **Early Babylonian Astronomy:** it included the period 2500BC - 750BC with many achievements such as
   - Control of the horizontal and the periodical phenomena for the heavenly bodies.
   - Schematic numerical Functions and Linear methods for heavenly phenomena.
   - Astrolabe texts and the Plough text (number of the big bear group and the routes of the goddess in the eastern side of the sky) then the motion of the planets and stars in those routes.
   - The calculations that involved the Zigzag function (triangle of day and night calculations hours by the use of the water watch with the passage of the year) and assigning the positions of the Fall Equinox and the Spring Equinox and the Summer Solstice and the Winter Solstice, then the calculation of Al Saros cycle that ranges 2/3 18 years.
2. **Non Mathematical Astronomy:** (during the period 750-350BC) it included special astronomical calendars like the daily diaries and the (almanacs) and texts for a certain year called goal year.
3. **Mathematical astronomy:** (from 350-50 BC) it included the important tables that are called "Ephemeris" and it also included lunar and planet Ephemeris, besides recording the movements of the planets near the zodiacal area and other astronomical subjects that are very important and which based on mathematical calculations namely those that lasted for long centuries after the year 50 BC.

In the next sections follow the important Babylonian astronomical achievements after they have been shifted into an astronomical scientific and mathematical language.

2. The Mesopotamian Achievements (3000 - 50 BC)

- The Babylonian approach to astronomy depended on two basic methods: Observation and Computation. Both are found in the earliest cuneiform texts (i.e., dated to the Old Babylonian Period).
- The main sources of the Babylonians from about 1800 BC to about 500 BC are the **Ea, Anu and Enlil** omen series, the circular and tabular "astrolabes" (i.e., planispheres), the MUL.APIN series, and various observational texts (i.e., reports to the Kings and the earliest astronomical diaries).
- From about 1800 BC to about 500 BC the main phenomena the Babylonians sought to be proficient with were:

(1) The appearance and disappearance of Venus;
(2) The duration of day and night;
(3) The rising and setting of the moon;
(4) Planetary and stellar risings and settings. All appear within the proteases of the celestial omens of the 2^{nd} millennium period (i.e., the Ea, Anu and Enlil series).

3. The Sumerian and Akkadian Period (3200-2000 BC)

During this period the Sumerians watched the sky and defined and named some of the constellations and planets. Most of the names of celestial bodies were Sumerian throughout the later periods and some of them at least must have Sumerian origins.

4. Babylonian, Assyrian and Chaldeanian era (2000 - 50 BC)

I) The old Babylonian Period In this period the recorded phenomena were:
- (1) duration of day and night (before and after 750BC);
- (2) rising and setting of the moon;
- (3) Appearance and disappearance of Venus.

II) The Period (1500-750BC)
- The composition of the great Omen Series "Ea, Anu and Enlil."
- Exact observations of the heliacal risings of fixed stars.
- Observations of daily risings, culminations, and settings.
- Composition of the circular and rectangular Astrolabes before 750 BC.
- A very primitive representation of the Venus phenomena by arithmetical sequences.
- Calculations of the lengths of day and night by increasing and decreasing arithmetical series

III) The Late Assyrian Period (750-600 BC) The systematic observation of celestial phenomena began in the Assyrian Period and continued without a break into late Seleucid times (Astronomy of the MUL.APIN series).

The main astronomical achievements of this period were:

- Detailed study of the fixed stars, their risings, culminations, and settings.
- Calculations of the duration of daylight and the rising and setting of the moon by "linear methods".
- Recognition of the zodiac as path of the Moon, the Sun, and the planets.
- Establishment of zodiacal constellations.
- Position of the zodiac with regard to the zones of Enlil, Anu, and Ea.
- Establishment of the seasons of the year.
- By about 750 BC the calendar became astronomically regulated by the risings of stars and constellations.

IV) The Chaldean Period (600-500 BC) In this period the main astronomical features were:

- Progress towards the division of the zodiac into 12 signs of 30 degrees each.
- Systematic observation of the Moon and the planets, their positions in relation to the fixed stars, their first and last visibility, stationary points, conjunctions, etc.

V) Neo-Babylonian, Persian and Seleucid Periods (500-50 BC)

- Mathematical astronomy. The largest and most highly developed part of the theoretical astronomy of the Seleucid period is devoted to the computation of the new moons.

The astronomy of the Neo-Babylonian and Persian period has the following typical features, (Ahmad, 2003):

- Systematic, dated and recorded observations of eclipses and lunar and planetary phenomena.
- Calculation of Periods.
- Prediction of eclipses.
- Division of the zodiac into 12 signs of 30 degrees each.
- Rise of horoscope astrology.
- Development of mathematical astronomy.

The most important achievements of this period are:

- Determination of accurate periods for the Sun, the Moon, and the planets.
- Calculation of the motion of the Sun, the Moon, and the planets, of eclipse magnitudes and other lunar and planetary phenomena. (These calculations were based upon an admirable mathematical theory.)

5. Babylon and Sumerian Records of Eclipses

1. Babylonian clay tablets that have survived since dawn of civilization in the Mesopotamian region record the earliest total solar eclipse seen in Ugarit on May 3, 1375 BC. Like the Chinese, Babylonian astrologers kept careful records about celestial phenomena, including the motions of Mercury, Venus, the Sun, and the Moon on tablets dating from 1700 to 1681 BC.
2. Later records identified a total solar eclipse on July 31, 1063 BC, that "turned day into night," and the famous eclipse of June 15, 763 BC, recorded by Assyrian observers in Nineveh. Babylonian astronomers are credited with having

discovered the 223-month period for lunar eclipses. One of the famous total solar eclipse recorded was the one on 15^{th} of April, 136BC. Many stars and 4 planets were seen (Stephenson, 1982)

3. The regular & recorded observed lunar phenomena:
   a) Observed just after New Moon on the evening of first visibility of the crescent time between setting of sun and moon on the evening of the first visibility of the crescent.
   b) Observed just before and after Full Moon.
      - Time between the last setting of the moon before sunrise and sunrise.
      - Time between the last rising of the moon before sunset and sunset.
      - Time between sunrise and the first setting of the moon after sunrise.
      - Time between sunset and the first rising of the moon after sunset.
   c) Observed on the day of last visibility of the moon in the morning.
      Time between the rising of the moon and sunrise on the morning of last visibility of the moon just before New Moon.

6. The most important achievements of Babylonian Astronomers

- Saros : 223 Synodic months = 242 Nodical months (18yr + 10.3 day eclipse period).
- Lunar disk divided into 4 sectors ; S = Akkad , N = Subartu , E = Elam, W = Amurru
- The discovery of Linear Zig-Zag function.
- The discovery of Step Function (Width of the 12 Zodiacs: 30^o).
- Prediction of the Lunar & Solar Eclipses.
- Astronomical Diaries, Almanacs, eclipse reports, goal-year texts and Ephemeris.
- The use of the 7^{th}, 4^{th}, 12^{th} and SEXAGESIMAL Systems.
- With the exception of the Venus tables of Ammiza-duga, which probably originated in the seventeenth century BC, most of the surviving Mesopotamian astronomical texts were written between 650 and 50 BC. These clay tablets with cuneiform writing are called astronomical diaries, and they are the unmistakable observations of specialists: professional astronomer-scribes.
- A typical diary entry begins with a statement on the length of the previous month. It might have been 29 or 30 days. Then, the present month's first observation - the time between sunset and moonset on the day of the first waxing crescent - is given, followed by similar information on the times between moonsets and sunrises and between moonrises and sunsets, at full moon. At the end of the month, the interval between the rising of the last waning crescent moon and sunrise is recorded.
- When a lunar or solar eclipse took place, its date, time, and duration were noted along with the planets visible, the star that was culminating, and the prevailing wind at the time of the eclipse. Significant points in the various planetary cycles were all tabulated, and the dates of the solstices, equinoxes, and significant appearances of Sirius were provided.

- The Babylonian astronomers used a set of 30 stars as references for celestial position, and their astronomical diaries detailed the locations of the moon and planets with respect to the stars. Reports of bad weather or unusual atmospheric phenomena - like rainbows and haloes - found their way into the diaries, too. Finally, various events of local importance (fires, thefts, and conquests), the amount of rise or fall in the river at Babylon, and the quantity of various commodities that could be purchased for one silver shekel filled out the diligent astronomer's report.
- By the sixth century BC, Neo-Babylonian astronomers were computing in advance the expected time intervals between moonrise or moonset and sunrise or sunset for various days in the months ahead. These calculations were based on systematic observations. Later, when combined with numerical tabulations of the monthly movement of the sun, the position of sun and moon at new moon, the length of daylight, half the length of night, an eclipse warning index, the rate of the moon's daily motion through the stars, and other related information, these computations enabled reasonably detailed and accurate predictions of what the moon would do and when it would do it (Ahmad, 2003).

7. Stars of Gods Paths

Enlil Path: it contains 33 stars including star groups (Cassiopeia, Orion, Auriga, Cancer, Lion, Corona Borealis, Big dipper or Ursa Major, Dragon, Ursa, Hydrus, Alnaser, Vega, Andromeda as well as Jupiter.
Anu Path: it contains 23 stars including (Aries, Pisces, Pleiades, Scera, Virgo, Canis Major, Algorabe, Lira, Al-Nekab and Al-Dewan).
Ea Path: it contains 15 stars including (Pisces Austrians, Aquarius, Centaurs, Lapus, Scorpios and Bootes.

8. Astronomy in the Islamic era (700 - 1400AD)

- Islamic astronomy became the western world's powerhouse of scientific research during the 9th and 11th centuries AD., while the Dark Ages engulfed much of the rest of the western world.
- The works by Ptolemy, Plato, and Aristotle were translated, amplified upon and spread throughout the Muslim world.
- **Al-Khwarazmi** developed the first table's trigonometric functions, c. 825 A.D., which remained the standard reference well into the modern era. Al-Khwarazmi was known to the west as "Algorism" and this is, in fact, the origin of the term 'algorithm'. Al-Khwarazmi's calculations were good to five places, allowing for unprecedented precision in astronomy and other sciences (Al-Moemeni, 1992).
- **Al-Battani**, c. 850 A.D., began with Ptolemy's works and recalculated the precession of the equinoxes (Nallino, 1969), and produced new, more precise astronomical tables. Following a steady series of advances in Islamic trigonometry, observations by **Ibn Yunus** of lunar and solar eclipses were recorded in

Cairo, c. 1000 A.D. Ibn Yunus is regarded as one of the greatest observational astronomers of his time (Al-Naimiy, 1993).

- The pace of Islamic science and scholarship eventually slowed down in the 14th and 15th centuries. Many great books and great ideas of the Islamic Age lay fallow for hundreds of years until they were finally translated into Latin and fueled the European revolution in thinking and the birth of science as we know it today
- We have made statistics for the Muslims Scientist's contributions (Published Books, Encyclopedias, Ephemerides(Al-AZYAJ)...etc. during the era 7^{th} up to 14^{th} centuries, we found that the highest numbers of contributions were during the 9^{th} and 10^{th} centuries (Al-Naimiy, 1993).
- The Muslim's astronomical contributions in comparison with others have been tabulated in Al-Naimiy (1993).

9. Summary and Conclusion

Babylonian astronomical achievements during 2500-50BC

- SEXAGESIMAL: it was used in calculation, weighing, time measurement, length and width lines and triangles.
- Astronomical calendars and tables, which were derived from calculation and observations (for religious, world and astronomical sakes), a model for Jewish, Greek and Roman calendars.
- Weather change notices as a function of Moon position or Sun position in the signs of Zodiac.
- Dividing signs of Zodiac belt to 12 signs, Moon phases to 28 as well as the appearance of the principle of apparent Sun movement in the celestial globe, which are the principles determining the eclipse period.
- Naming of some stars and constellations, which could be seen by mere eye, especially signs, with animal or Kings or Gods names; some of them were based on certain myths.
- Name of twelve months, which are used in the Arab East.
- Week base according to the four Moon forms: they have had a special importance for the beginning of the month, seventh day, fifteenth day and the end of the month, where festivals and celebrations were made, victims were slaughtered, and washing was done. Sometimes Kings attended to do some business.
- Use of the lunar calendar.
- The discovery of leap rule: adding a full month every three lunar years in order to make the lunar and solar years identical, then leaping 7 times every 19 years, a day every three lunar years to make the year 355 days. As well as the famous Babylonian equation (235 months = 19 solar years).
- Calculation of the solar year (365 days and 6 hours and 50 minutes and 15 seconds), within an error of ± 6.5 minutes.
- The discovery of Saros round (18.6 years), the period between two sequenced eclipses.
- Observing planets in order to make prediction about weather. Observing Venus in order to know fortune and to fix calendars and dates of religious festivals and

to make prediction about weather. They knew the period of its conjunction (584 days) and its appearance five times at the same place every eight years.

- Dividing the day into 6 equal parts, 3 for the night and 3 for the day, each part= 2 Beru, Beru = doubled hour, day = 12 doubled hours divided into 360 Uses.
- There is a special meaning for the number 7 in their daily life (sky=7 levels, week=7, planets=7, winds=7)
- Picture and engraves, in the cylinder seals, contained balls and circles rounded by balls or smaller circles rounded by moons. This may indicate that they have recognized the theory of centrality of the Sun.
- The discovery of the first linear **zigzag** functions describing the difference in the day duration. They used this function for the lunar and astral phenomena in the astronomical texts as well.

Lastly, I want to indicate that, the Babylonian astronomical achievements described here may be a small part of the total: there are hundred thousands of unread mud inscriptions as well as damaged ones. They are all great achievements, and most of them are still used in the present days.

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