The Canadian Society for Mesopotamian Studies
La Société canadienne des études mésopotamiennes

B U L L E T I N

39

September 2004

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ISSN 0844-3416

The Legacy of Ancient Near Eastern Astronomy

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Résumé

Mon propos dans cet article sera d'attirer l'attention sur les aspects de la tradition astronomique du Proche-Orient ancien qui ont influencés d'autres traditions et spécialement celle qui, partant du monde gréco-romain et empruntant diverses routes, aboutit à la science moderne dite "occidentale". Ces chemins incluent la métrologie, les noms d'objets comme les constellations, les pratiques astrologiques, les rapports d'observation et les éléments de la théorie astronomique. Contrairement à ce que les auteurs classiques ont affirmé au sujet des origines de leur science, l'Égypte semble avoir beaucoup moins contribué, que la Mésopotamie l'a fait pour le monde gréco-romain, à l'essor de l'astronomie sauf dans la mesure du temps; cependant, l'Égypte a pu servir de lieu où l'astronomie babylonienne lunaire et planétaire a survécu sur le plan pratique parmi les astrologues durant les premiers siècles de l'empire romain lorsque les centres babyloniens étaient à leur déclin.

When historians of astronomy try to locate the end of ancient and the beginning of modern astronomy, they often situate Johannes Kepler (1571–1630) at the boundary. Copernicus had set out his sun-centred cosmology in terms that would have been fully intelligible to a Greek astronomer fifteen hundred years earlier, with the planets borne around the sun as part of a complex mechanism of circular movements traced out by spinning spheres of etherial matter. The observations of Tycho Brahe and Galileo did away with the etherial spheres, but it was Kepler who first addressed the task of mathematically and physically describing a cosmos in which forces incite heavenly bodies to fly about one another other along elliptical paths. Kepler himself thought of his work as a fundamentally new approach (the book in which he first deduced the elliptical orbit of Mars is entitled *Astronomia Nova*, "The New Astronomy"), but at the same time as the culmination of a tradition dating back more than two millennia.

He portrayed that tradition, and his place in it, in an elaborate frontispiece to his *Rudolphine Tables* (1627). The Temple of Urania (i.e. Astronomy), capped by an elliptical dome of Kepler's own devising, comprises ten columns representing the great astronomers of the past. By the front pair, elegant classical columns, we see Copernicus and Tycho. Further back are four less handsome brickwork columns, representing the ancient Greek astronomers Meton, Aratus, Hipparchus, and Ptolemy (Hipparchus himself is leaning against one of the columns on the left, while a turbaned Ptolemy sits by one of the right ones). Still further back are a pair of columns made of rough stone blocks, and at the extreme rear, two logs on which the stumps of the branches remain, and that do not quite reach the base of the dome. Standing by these coarse and inadequate supports is a man

Fig. 1. Kepler's frontispiece to the Rudolphine Tables.

technique and engineering.

Egyptian astronomical time reckoning took its starting point, curiously enough, from the problem of subdividing the night into shorter intervals. This was accomplished by identifying thirty-six constellations, the so-called "decans," whose successive risings taken together with knowledge of the current date indicated the current time. By an obscure process this scheme led to a division of both the night and the day into twelve time units ("seasonal hours"). In practice times during the day were measured by shadows. Among the surviving Egyptian astronomical instruments are portable shadow-clocks and simple water clocks, the latter being intended for reckoning time during cloudy nights.

Units and Conventions

The great part of ancient astronomy had to do with the night sky and the objects visible in it, essentially the stars, planets, and moon. The irregular pattern of stars provided a recognizable background for the movements of the moon and planets, and both the Egyptians and the Mesopotamians thought of the brighter stars as forming groups or constellations that, in a rather impressionistic way, suggested pictures of people, animals, or other familiar objects. Of particular importance in Mesopotamian astronomy were those constellations that made up a belt within which the moon and planets travel. The principal contellations in this "path of the moon" were listed in the Babylonian handbook MUL.APIN, many copies of which survive from the Neo-Assyrian and Neo-Babylonian periods. We can identify the approximate counterparts of most of them in the system of constellations that we inherited from the Greeks and still use.

The Stars	Pleiades
Bull of Heaven	Taurus (Bull)
True Shepherd of Anu	Orion
Old Man	Perseus
Crook	Auriga (Charioteer)
Great Twins	Gemini (Twins)
Crab	Cancer (Crab)
Lion	Leo (Lion)
Furrow	Virgo (Virgin)
Scales	Libra (Scales)
Scorpion	Scorpius (Scorpion)
Pabilsag	Sagittarius
Goat-Fish	Capricorn (Goat-horn)
Great One	Aquarius (Water-bearer)
Tails of the Swallow	part of Pisces (Fishes)
Anunitu	part of Pisces
Hired Man	Aries (Ram)

Obviously many of the pictures are essentially the same. It appears that when Greek astronomers established a more or less complete system of constellations to cover the stars that they could see (which must have happened by the early fourth century B.C. but perhaps not long before that), they incorporated many Babylonian constellations.

Another obvious fact about the list from MUL.APIN is that it includes all the twelve familiar zodiacal constellations as well as some others. The standard zodiac was another valuable invention of Babylonian astronomy, dating roughly to 500 B.C., and apparently motivated by a desire to simplify the tracking of the motions of the planets and moon from day to day. The essential innovation here was not merely reducing the list to twelve constellations, but also treating each of the twelve as an equal stretch of the complete belt, regardless of whether the associated constellation was relatively large or small. This amounted to setting a uniform scale of distances (or, as we would say, of angles) along the belt. Each of the twelve divisions was further subdivided into thirty subsections, making a total of 360, the direct origin of our degree unit of angle measurement. And since Babylonian numerals were written using a base-sixty place value system, fractions of a degree were expressed as sixtieths, sixtieths of sixtieths, and so forth, from which we get our minutes and seconds of arc.

On the other hand, our time units have a mixed Egyptian and Babylonian origin. As I mentioned above, the Egyptians divided daytime and nighttime into twelve seasonal hours, and this convention, which is convenient for sundials, was taken over by the Greeks and Romans. Seasonal hours vary in length through the course of the year, with the longest diurnal hours in the summer and the longest nocturnal hours in the winter. However, certain methods of reckoning time, such as waterclocks and star risings, result in time units that do not vary in length with the seasons, so that it is not surprising that we find in some Egyptian texts references to a constant hour, one twenty-fourth of a complete day and night. Greek astronomers preferred to work with these "equinoctial hours" because they were constant time units—for the same reason, as late as Copernicus' time they liked to measure longer times by the Egyptian calendar with its contant 365-day years—and eventually the prevalence of mechanical clocks put an end to seasonal hours. If we subdivide our Egyptian hours in the Babylonian fashion, into sixtieths and sixtieths of sixtieths, this is because the Greeks found that the Babylonian place value system was much more suited to doing arithmetic with measured quantities than Egyptian fractions.

Astrology

The word "astrology" can refer vaguely to the belief that celestial phenomena affect our lives (beyond such obvious connections as that between the sun and the seasons), or more specifically to the complex system of interpretation and forecasting practiced by most contemporary astrologers. This system, which makes much use of the concept of the horoscope (the configuration of the sun, moon, and planets in the zodiac and of the zodiac relative to the local horizon for a

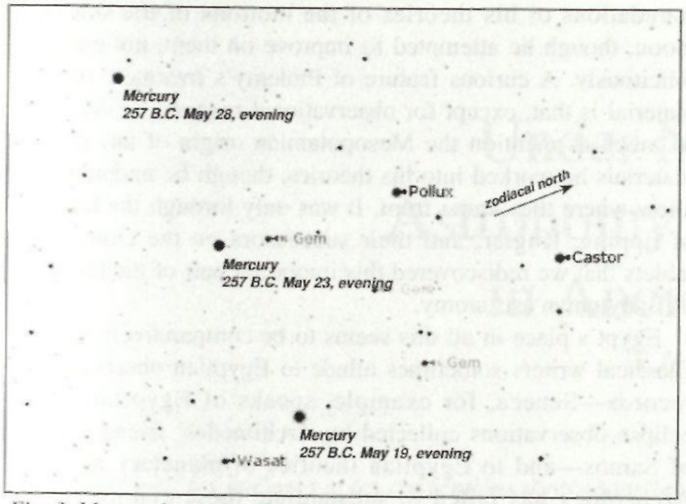

Fig. 3. Mercury's motion through Gemini in 257 B.C. The cuneiform tablet BM46231 records Babylonian sightings of Mercury "four cubits below" the star Castor on the evening of May 19 and "below" Pollux on May 23. Five days later, according to Ptolemy, a Greek astronomer in Egypt saw Mercury making a straight line with the two stars.

given time and place), is essentially a Greek invention that was transmitted widely in the ancient and medieval world. Before the eighteenth century—and still later in some milieus, for example India—this astrology was generally regarded as an intellectually respectable, scientific discipline. It had a large role in the spread and survival of technical astronomy, on the results of which it depended, and to some extent it also dictated the priorities of astronomical research.

The ancient Greco-Roman literature on astrology claimed that it was a science of great antiquity, primarily Egyptian in origin but with Chaldean roots as well. Historical scholarship of the last hundred years or so has shown that this account is not quite true. The Greek style of astrology cannot be shown to have existed before about 100 B.C., before which most allusions to anything that looks like astrology probably refer to Mesopotamian celestial divination. Mesopotamian omen lore in fact spread very widely in antiquity, and versions of Babylonian celestial omens reached Anatolia and even India. During the period of Persian domination in the mid first millennium B.C. the Egyptians began to use forms of Babylonian omens, for example interpretations of eclipses, adapting them to local geographical and political conditions.

Thus it seems to have been in Hellenistic Egypt that the inventors of Greek astrology found much of the pre-existing Near Eastern material that was subsumed into the new science, but very little of this material was ultimately Egyptian in origin. The single most important element that Greek astrology owed to its predecessors was the horoscope, which is an elaboration of a kind of document known in Babylonia as far back as the fifth century B.C. The Babylonian horoscopes were compilations of phenomena that occurred in the heavens on or close to the date of birth of an individual, selected with a view to interpreting the astronomical data as omens for the life and character of the person in question. They tended to draw more on the observational records than on mathematical computations, whereas the Greek horoscopes are wholly computed from astronomical theory and represent an instantaneous "snapshot" of the cosmos. Several technical concepts used in interpreting Greek horoscopes were also Babylonian. The only real Egyptian ingredients were the decans, which had metamorphosed from constellations used for time reckoning to subdivisions of the signs of the zodiac used for astrological interpretation.

Astronomical Science

Astronomy differs from other physical sciences, such as physics and chemistry, in that its objects of study were, until space travel began in the 1950s, entirely out of reach. Early astronomers could not solve problems by setting up experiments; they had to wait for the right situation to come about in the sky of its own accord, or, if possible, they could search past records of observations that usually had been made for entirely different purposes. The most fateful development in ancient astronomy was the as yet unexplained decision of Babylonian observers in the eighth century B.C. (or perhaps earlier) to preserve records of observations of eclipses and other lunar and planetary phenomena furnished with exact dates and fairly precise locations of the heavenly bodies relative to the stars, that is, the kind of quantitative information on which any advanced theories of celestial motions would have to rely. The astronomical archive in Babylon was kept up, with surprisingly few changes in

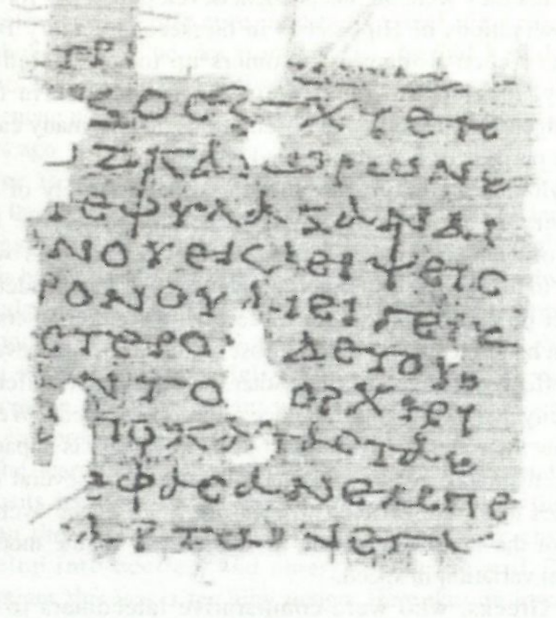

Fig. 4. A tiny (3 by 3.5cm) scrap of papyrus with a fragment of a Greek text from the second century A.D. mentioning elements of Babylonian lunar theory and, probably, the city of Uruk. Uruk is one of two sites (with Babylon) where tablets of mathematical astronomy have been found.

observational habits, for seven centuries, a span of time unrivalled by any observatory in history.

The historical significance of the Babylon archive is twofold. First, it was the source of empirical data for the development of astronomical theories. The Babylonian scribes themselves had direct access to the entire archive, and the mathematical astronomy that they practised during the last three centuries B.C. was surely constructed in large part by analysis of information derived from the Diaries. Greek astronomers such as Hipparchus and Ptolemy would not have had this full access (not least for linguistic reasons), but someone translated selected material from the cuneiform tablets into Greek, including a fairly full run of lunar eclipses, which proved essential for the development of models for the motion of the moon. The Babylonian observation reports in Ptolemy's *Almagest* are all that survives of these translations. But now that a significant fraction of the original archive is again readable through the labours of Assyriology, Babylonian observation reports are again making a contribution to modern astronomical and geophysical research, in particular the study of the changing rate of rotation of the earth.

The second way in which the archive affected subsequent astronomy was as the probable inspiration for other observational programs elsewhere. As well as observation reports originating in Babylon, Ptolemy's *Almagest* quotes several observations of the moon and planets that were made in Egypt in the third century B.C. by at least two "teams" of astronomers. Although by no means identical in their conventions to the Babylonian reports, these Greco-Egyptian reports provide the same kind of information, and it is hard to believe that they were an independent development. As for the later observations of Hipparchus in the second century B.C. and later Greco-Roman astronomers up to and including Ptolemy, there is no doubt that they were made in full knowledge of the Babylonian observations, and in many cases with the purpose of being compared with them.

Babylonian astronomical theory consisted largely of the discovery of mathematical patterns that describe the repetitions and changes of astronomical phenomena well enough to allow one to predict the phenomena independently of direct observation. In order to do this, the astronomers of Babylon had to tease out of their observational records several cyclic effects that overlay each other, each having a different periodicity and a different influence on the phenomena. We do not know their analytic methods, but their success is apparent in the remarkable accuracy of their estimates of several key quantities that were difficult to measure, such as the average length of the lunar month and the periodicity of the moon's principal variation in speed.

The Greeks, who were comparative latecomers to the practice of astronomical record-keeping, were in no position to arrive at such knowledge independently. Again it is Hipparchus in the second century B.C. who first seems to have availed himself of the advanced results of Babylonian theory. Ptolemy also took these Babylonian numbers as the foundations of his theories of the motions of the sun and moon, though he attempted to improve on them, not entirely felicitously. A curious feature of Ptolemy's treatment of this material is that, except for observational records, he does not so much as mention the Mesopotamian origin of any of the materials he worked into his theories, though he undoubtedly knew where they came from. It was only through the labours of Epping, Kugler, and their successors on the cuneiform tablets that we rediscovered this important part of the heritage of Babylonian astronomy.

Egypt's place in all this seems to be comparatively minor. Classical writers sometimes allude to Egyptian observational records—Seneca, for example, speaks of Egyptian solar eclipse observations collected by Archimedes' friend Conon of Samos—and to Egyptian theories of planetary motion. Archeology has failed to substantiate these claims for an astronomical tradition in Egypt paralleling Mesopotamian astronomy in its methods and interests. Perhaps we have just been unlucky, but most modern historians are inclined to suppose that our Greco-Roman informants were mistaken. Papyrus fragments of astrologers' manuscripts and tables show that the most plausible case for an Egyptian role in the development of astronomical research is as the place where Babylonian lunar and planetary astronomy lived on at a practical level among astrologers during the first centuries of the Roman Empire, when the Babylonian centres were in decline.

FURTHER READING:

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