***"A Modern Approach to Assyrian-Babylonian Astronomy"***

SALVO DE MEIS

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# A Modern Approach to Assyrian-Babylonian Astronomy

Assyrian-Babylonian Astronomy is on a great way to show most of its important features, after a little more than a century from the beginning of its true discovery and study.

I shall not repeat, although due, the celebration of the efforts of the Fathers Founders of Assyriology: Epping, Strassmaier, Kugler, Schaumberger, neither of the researches which followed, especially those of P. Victor and Otto Neugebauer, Karl Schoch, Abe Sachs, until Simo Parpola, Hermann Hunger, Peter Huber, Giovanni Pettinato. This immense enterprise is well known to scholars for the results obtained in such a short time, and its works stand in front of us as a monument *aere perennius*.

It is however interesting to go somehow into details to show the difficulties of these researchers, in order to consider the great advantages that we have at present, to repeat their studies and, whenever the case, try to improve or update them, or to apply the methods to other civilizations.

To do this, a full humbleness is due, also because now we can take advantage of the results achieved, and because we have more powerful tools at our disposal: texts, transliterations, translations, photos, dictionaries, computers.

While our Fathers, to call them shortly so, had just pen, paper and brain, we have a safety layer from which to start: their works.

Just to have an idea of them, look at the figure 1: it is the conclusive table in Epping's "Astronomisches aus Babylon,"[1] the result of years of deciphering, calculating, trying and trying again solutions to the questions put forward by the clay tablets.

First of all we must admire the systematic and useful layout, something we would often like to have handy: the names of the months, the words for time divisions, the names of planets, zodiacal signs, orientation, and finally of stars, all with the cuneiform ideogram, transliteration, translation.

Remarkably the stars mentioned are just six; only about 1907 Schiaparelli was able to identify 118 stars.[2]

This is perhaps the most striking aspect: all the names are derived from comparisons of many texts, from the calculation of astronomical positions to check any proposed identification, from the painful interpretation of the cuneiform signs in many and many tablets.

Epping, modestly, states that it was easy to understand numbers and some words, but this is not a simple task, because only who commands astronomy, especially positional astronomy, can direct the research in such a way to understand that a tablet has data on lunations,

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[1] Epping 1889.

[2] De Meis 1999, 63-80.

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planetary motions, stars, when nothing is known of its contents, and the figures have to speak by themselves. Strassmaier and Epping were in continuous exchange of data, translations, improvement of results, and we find here another advantage which we have at present: Epping was at Quito, Strassmaier some thousand kilometers away, and mail was not so fast as it is today, they had no fax or e-mail and all had to be hand-written, mailed, sent back and forth.

So, although obvious, we are in a privileged condition which we often forget.

The other aspect is that the command of astronomy meant calculating by hand thousands of positions to be sure of the correspondence of the text to the calculations.

Of course this is true for all scientists; I am always amazed at the enormous quantity of hand calculations, generally without errors, when I see the manuscripts of Galileo, Gauss, Schiaparelli, Neugebauer, just to mention a few names.

But a main consideration is in order. The first calculation of Epping was that of New Moon, first the interpretation of the texts, the enlightening discovery that they referred to Moon phases, then the calculations.

Well, by hand this is lengthy, painful, subject to errors; anyone who has tried this kind of exercise can appreciate the efforts and time needed. Now, with the touch of a few computer keys we obtain exact results in fractions of a second.

The ephemeris table for the Moon in SE 189 (–122/–121), SE 188 (–123/–122), SE 201 (–110/–109) must have required hours, if not days, of calculations (again, a few seconds of computer time), besides the comparisons of Babylonian and his calculations, which occupy many pages of that precious book, small in size, great in knowledge (Fig. 2).

Without insisting too much, I shall only mention the computing of the Chaldean ephemerides as he called them, and of their errors [p. 68–80], the calculations of solar and lunar eclipses [pp. 103–108], the conjunctions of the Moon with stars, the planetary conjunctions with stars [pp. 114–134], the oppositions and stations of planets, their heliacal rising and setting [pp. 140–148], and last but not least, the drawings of the kudurrus with astronomical meanings, also important at present (Fig. 3), all this at a time when even the astronomical terms had to be deciphered. I have recalculated these events and found Epping's values correct.

All this was masterly continued by F.X. Kugler, O. Neugebauer, A. Sachs and other scholars.

And to conclude on this aspect, I must say that the same great knowledge and experience has to be credited to Simo Parpola, who some three decades ago calculated by hand the astronomical phenomena mentioned in his highly acclaimed "Letters from Assyrian Scholars to Kings Esarhaddon and Assurbanipal,"[3] a huge enterprise to give scholars an enormous quantity of documents, parallel to the work of A. Sachs for Babylonian Diaries, continued by H. Hunger.[4]

Let us now have a brief look at the advantages offered by modern techniques, and some suggestions to use them in the study of the astronomical part of cuneiform texts.

Amongst the main purposes is the dating of a text. As it is well known, even if a date was written in a tablet, often it is broken or otherwise illegible. If we are lucky enough to find a relatively

[3] Parpola 1970. Also mentioned as LAS.

[4] Sachs-Hunger 1988, 1989, 1996.

clear date, this might refer to a regnal or accession year of a king, to a year of the Seleucid Era, and in this case we have tools such as Parker-Dubberstein 1956,[5] with extensions by Parpola (LAS, Appendix J) or Peter Huber[6] ("Astronomical Dating of Babylon I and Ur III").

If we want a closer accuracy, then we can update some of the data with new findings, and write a computer program to calculate Babylonian dates from Julian ones and viceversa.

This will allow us a faster search, and avoid jumping from a publication to another. In fact, when dating a tablet, it is necessary to perform several calculations of the same type, and an enormous saving of time is achieved by the computer because it is fast, and, if well programmed, is less subject to errors than a human, and can incorporate several documents to be consulted at once.

An immediate check for example is that of dates which fall on intercalary months or on a definite month; moreover the inverse calculation is also fast, an advantage if we are trying different dates.

This first step of the humanist has to be followed by the astronomical computing of the events supposedly occurred in the period supposedly covered, to take care of scribal errors, wrong data and similar occurrences; and also this requires repetitive calculations better made by the computer.

But what should we compute first? Of course, the events which are rare, such as Solar and Lunar eclipses, Lunar occultations ("the star xx entered the Moon" is the usual quotation), Lunar conjunctions of stars or planets, Lunar phases, heliacal phenomena (the so-called Greek-Letter Phenomena).

Again, though not so easy, these phenomena can be calculated by proper computer programs, and here is a first advice and caveat.

It is much commendable that an Assyriologist takes the trouble of computing astronomical events, but there are several objections to this. Generally the Assyriologist is mainly a philologist, historian, humanist and the command of astronomy is not his main "cultural luggage." Epping and Strassmaier cooperated, each one for his own specialisation; so, there is nothing bad if after the first trials, the Assyriologist asks an astronomer to perform the calculations. What is important is that from the contents of the tablet he has a good idea of the text, the time range of historical events (if mentioned or guessed), the names and the astronomical events quoted, if this is possible.

The reason is that independent calculations should always be performed to arrive at common results: only the convergence of philological, historical and astronomical data gives a high probability of a certain dating.

The disadvantage is that modern astronomers are much more expert in big bang theories or other astrophysical questions, than in calculating heliacal phenomena or lunar occultations. Hence it is necessary to find one who is conversant with the calculations of the ancient astronomical phenomenology. And, incidentally, this raises the question of how and when our Universities will start interdisciplinary courses to this purpose.

Another consideration refers to the use of commercial computer programs, however advertised. No program can properly calculate all the phenomena described in Babylonian astronomy, as several programs are needed and linked, and com-

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[5] Parker-Dubberstein 1956.

[6] Huber 1982, 1999-2000.

mercial programs are far to meet the requirements of Assyriologists. A word of warning includes even very recent ones.

Ideally, one should write his own programs as Jean Meeus[7] often says, especially to know the limitations of the programs, the proper use of certain details and parameters, the necessity of including special data or conditions, in other words to know what to expect, not to have a blind trust on the program results, which may be wrong instead.

Just an example. Eclipses, solar ones especially, are most useful to date a historical document. In the near past, to avoid cumbersome and difficult calculations, one used to consult eclipse tables or "Canons." Tables gave rise to equivocal results: for example one would find a day in which an eclipse occurred, but that eclipse actually was visible elsewhere, and the table was silent on this. Oppolzer's "Canon der Finsternisse"[8] has been very useful, but normally one would not perform those lengthy calculations (with logarithms), which give good results, but would simply jump to the diagrams showing the eclipse path.

As Oppolzer himself wrote, these lines were drawn connecting three points by circular arcs, that is eclipse beginning, maximum and end. This often leads to errors, because the real lines are not circle arcs, and because that eclipse might have been observed within its northern or southern limits, not necessarily within the totality path, but the limits are not shown in the maps of many Canons, except those of Meeus-Mucke.[9]

Anyway, the question of total eclipses is limited for Babylon: as a matter of facts from –750 to the year zero there were only four eclipses visible from there as such, on –435 May 31, –401 January 18, –135 April 15 and –9 June 19, the other ones were annular (2 only) or partial.

Knowing this, one can look at Oppolzer maps and exclude totality even if the curve passes close to Babylon, but still there are cases where an eclipse which is represented far from that place was rather significant, although partial, and one could think that it was not visible instead. As an example, Fig. 4 shows a part of the Oppolzer map: the track of total eclipse of –302 April 2 passes almost exactly through Babylon, that of the annular one of –306 June 14 is quite far from the town. Accurate calculations shown in figs. 5 and 6, give that at Babylon the eclipse of –306 was only of magnitude 0.687, while that of – 302 was 0.880, contrary to what one would expect. Incidentally, to my knowledge, we have not yet records of these eclipses.

This shows the importance of accurate calculations by which the other maps have been calculated, with the centrality lines and the isomagnitudes. It is important to stress that by the computer it is possible to obtain accurate maps where precise positions are computed point by point, instead of hand drawings: another advantage in our studies.

Another example is the dating of occultations, either lunar or planetary. Generally one computes close conjunctions of the celestial bodies, what – if small in angle – may lead to the discovery of an occultation fitting our text. However, further calculations are needed, such as the local visibility of the event, the phase of the occulting body (Moon or planet), the altitude of the body above the horizon to check if the event, al-

[7] Meeus 1991.
[8] Oppolzer 1887.
[9] Meeus-Mucke 1983, Mucke-Meeus 1983.

though occurred, was in fact well visible from a given site, all in order that the results coincide with the text.

A simple reference is the lunar occultation of Mars quoted in Aristoteles, *De Coelo*, 12, 2, for which many dates have been proposed. However even if these occultations occurred at Athens, the conditions described in the text must be fulfilled, such as the Moon about half illuminated, Mars ingress from the dark side of the Moon and egress from the bright one, besides a suitable altitude on the horizon. These conditions eliminate all proposals, except the date of –356 May 4, also taking into consideration that some event occurred when the great philosopher was too young to observe and note the occultation. In fact he really observed the event, and did not report others, his words are: σελήνην ἑωράκαμεν διχότομον μὲν οὖσαν.

Hence we can conclude how misleading could be the simple browsing into eclipse catalogs or Canons, or to perform calculations without the necessary accuracy and care.

Another cause of errors is to omit in the calculations the value of Delta T (ΔT). This quantity is the difference between Dynamical and Universal Time, that is between a constantly running time and the actual perturbed time (due to the variations in the rotation of the Earth). It amounts to about six hours in –700, and this means that the actual visibility of a phenomenon occurs at a longitude about 90 degrees east of the point calculated in Dynamical Time. Fig. 7 shows how the track would be for the eclipse of –306 June 14 if ΔT were evaluated as zero, that is supposing the Earth to revolve uniformly and without rotational perturbations. Exact values of ΔT are subject to various considerations, however good mean values can be computed; to ignore ΔT is clearly a source of errors. Again, old catalogs and Canons either ignored ΔT, or gave wrong values, as the measurement and extrapolation of this variable is quite recent, especially by Meeus and Huber.[10]

Another warning concerns the difficult motion of the Moon (Newton said it caused his head to ache, which is something for such a genius!), which is quite fast, so its calculation needs thousands of correcting parameters, and they might not be known exactly or not all incorporated in a commercial program, so that the Moon results somewhere else when the Sun or other bodies are supposed to be eclipsed or, worse, occulted.

Also the positions of stars, if calculated without precession and proper motion, may give surprises, and lunar conjunctions – or, worse, occultations – fail the result, and we are tempted to exercise the usual attack to careless scribes, who really deserve no such insult.

The Melammu Project has several very positive aspects, and one is the creation of an astronomical database, which will free scholars from the errors and pains of many computations. This database will prove useful in the study of Babylonian civilization, besides of pure astronomical records.

Its structure for astronomy should be flexible, in order to accommodate for improved parameters or significant new ones and hence be always up-to-date.

It could be extended to list of kings, dated tablets, correlated terms in Assyrian, Akkadian and modern languages, metrological data, a sort of generalized "Planetarium Babylonicum" for the several facets of Assyrian and Babylonian

[10] Meeus 1991, Huber 1999.

culture, including its historiography.

A further advantage is in the calculations of events for which no definite dating is immediately possible, and in this case one will be able to put forward several proposals which can be confirmed by further studies. Also in this case computer applications prove very useful, saving large quantities of time and avoiding those inescapable errors of the hand calculations, but proposing to the humanist several possibilities from which he will choose according to his specific knowledge of text, philology, history.

Needless to say, recording in a proper magnetic support (CD, DVD, diskettes, tapes etc.) the texts, figures, words, will allow fast comparisons, listing, availability of all this material. Just think of having quickly available transliterated or transcribed texts, drawings and photos of archaeological interest. One could easily classify them, consult and compare them rapidly for new studies, for example to find the age of a kudurru or the kings named in texts. A recent example is the study by Basello for Elamite calendars.[11] And indeed the memory of recent available hard disks is such that it allows enormous quantities of data to be stored.

Besides the Melammu Project, I take this opportunity to mention with gratitude the great impulse given by Is.I.A.O., especially Gherardo Gnoli, with the Project for the History of Science in Ancient and Oriental World, directed by Antonio Panaino, active also in several specialized fields of Oriental Studies, which is giving fruits of important value, with creative intelligence, effort and great reliability of results.

Coming back to the topic of my talk, I shall quote two examples of interesting novelties, which I found for Babylonian eclipses, and which were possible because of the speed of calculation allowed by the computer.

Eclipse records often mention the presence of winds blowing in certain directions. I know 12 such cases of solar eclipses and 45 of lunar ones, either from the LBAT or the Diaries.

First, I noticed that in the not observed eclipses, those mentioned as “nu pap,” there is no mention of wind. This has something to do with predictions; as we shall see Babylonians could predict eclipses – contrary to former statements – but not to the extent of their complete appearance evolution as seen from a given site.

Second, the winds are actually blowing during solar eclipses, due to the fast temperature drop in the event, but this is not the case for lunar eclipses.

Then the possibility was that the winds could refer to the movement of the Moon with respect to the Sun in solar eclipses, or to that of the Earth shadow during lunar eclipses, as if the winds could cause the displacement of the shadow or of the Moon during eclipses.

So the computer helped, because the long calculations of many eclipses were reduced to reasonable times, including the entrance and exit angles for the main phases. Programs were written by Jean Meeus, whom I thank once again for his friendly cooperation, and by me.

The result is shown in fig. 8 for some solar eclipses. Here the wind direction mentioned results the incoming one, that is the Sun is fixed and the Moon moves; “gusty” wind refers to the changing directions of the darkened lunula, in the case of total eclipses. The figure represents three phases: first, maximum and

[11] Basello 1999.

last, and it is immediate to see that the scribes noted the movements of the Moon during the eclipse, when mentioning winds.

In a similar way one can investigate lunar eclipses and arrive to a conclusion hidden until now; in this case the wind refers to the motion of the Earth shadow with respect to the Moon considered fixed. Fig. 9 represents the partial lunar eclipse of –685 April 22, for which the text [LBAT 1417] says that the "West wind blew" and by looking at it one can see that the direction of the calculated shadow and that of the wind mentioned in the tablet are in agreement. This occurs for more than 45 texts, and should not be a simple coincidence.

Figure 10 shows some lunar eclipses, from –662 to –647, mentioned in LAS, which I have redrawn by computer, with less pain than Simo had to experience for a similar figure.

In the tablets studied here, which are not astrological, there is no mention of the directions of the shadow towards Elam, Amurru and the other lands, but the wind directions are stated as such.

Concerning the prediction of eclipses by Babylonians, for brevity I shall only show some diagrams, again using data from LBAT, the Diaries or the Reports to the Kings.

First of all often it is mentioned that an eclipse was expected but not seen or that "it was late," which requires a previous computation for such a statement. Second, we find that such eclipses rated "nu pap," that is eclipses known to occur, but not seen, were visible elsewhere than Babylon, but the times of the event are correct.

In fact the details of the calculations are too many to be exposed here, and it is more convenient to give the results. If one calculates the difference between the time T1, first contact, in the tablet and the corresponding computed New or Full Moon, the difference is very small, and can be called the "error." Thus we may suspect that the conjunction time was calculated, what Babylonians could do with no large difficulty.

One has for example from tablet ACT 122, column F, the Moon's speed calculated by System B. Fig. 11 shows the comparison of data from ACT 122 and calculations made according to the ELP 2000 theory of Chapront. As it can be seen, the differences are quite small.

Fig. 12 represents the error Babylonian–computed for the initial time T1 in solar eclipses. For 24 cases the mean error is 0.99 hours with a standard deviation of 4.17 hours, but, excluding errors larger than 3.5 hours, as shown in the figure the mean error drops to –0.41 hours with a standard deviation of 1.53 hours! This is a surprisingly small difference, which even nowadays an astronomer would not be able to calculate by additions and multiplications only. It is also interesting that the computing technique improved with respect to time, as the line of tendency gets closer to zero with increasing time. Also the next figure shows the error distribution, which is close to a normal one.

In a similar way the errors for lunar eclipses have been calculated for 53 eclipses and the mean value is 0.17 hours with a standard deviation of 0.6 hours.

Due to lack of geographical knowledge and relative sizes of Sun and Moon, and in the absence of physical theories, the prediction of visibility from a given place was not possible, still what is important is to document that predictions were made with a remarkable accuracy, obtained by other astronomers much later.

Still, we do not know exactly how these calculations were made, although lists of eclipses by the Saros cycles are known, the so-called Saros canon, their accuracy is not the same of the predictions studied, and the tablets are there to put us questions after millennia.

As a further example of cooperation between humanists and astronomers, I would like to quote a recent example. Tommaso Gnoli has made a deep study, C. Furius Sabinus Aquila Timesitheus, concerning episodes in *Historia Augusta*. A solar eclipse is mentioned there in relation to Gordianus acclaimed as the only emperor. We made a search of eclipses visible at Athens, as clearly detailed in Gnoli's paper, finding that the best candidate for the eclipse mentioned was the total one of 240 August 5, which was large at Athens and total at Sunion, what might have given resonance to the event, as occurred in such a sacred place. Gnoli had therefore an astronomical confirmation of his historical research.

Further application of modern tools may be found in the software for images, or for language analysis, data analysis, graphic representations.

For example one could efficiently use image software to reproduce cuneiform texts and put easily interlinear transliteration or translation, indicate on images particular remarks or signs, which once had to be made manually (a by-product is that printing-proof correction becomes very limited, as it is now for camera-ready texts); preparation of indexes, glossaries, list of frequencies of words or names, and similar applications.

From a computing point of view, data analysis software results particularly important when series of observations are to be studied, and their relationships determined. A recent study by Peter Huber on Delta T has lead to conclusive results on the basis of statistical analysis, and in the present study I have used his formula, with programs by Jean Meeus for the theories ELP-2000 by Chapront (Moon) and VSOP 87 by Bretagnon (Sun and Planets).

Graphic representations are widely increasing their useful role in scientific texts, showing the evolution of particular phenomena either of physical or of general nature, and they are quite easily made now.

Another recently introduced software is dedicated to the analysis of sentences, Akkadian in particular, so that so called "tokens" are grouped in order to obtain something like automatic translation (from the transliterations), and, more efficiently, to discover special interpretations which will help not only beginners but experienced Assyriologists as well, in the search for significant connections. A recent work by G. Graßhoff[12] is a good example of this technique, applied to Normal Stars and Lunar Six observations, with results which are either new or confirm those already known.

Also, the fundamental study by John Britton[13] "Lunar Anomaly in Babylonian Astronomy" is a splendid example of the use of computer and brain, with the help of mathematical and graphic analysis and the impressive amount of calculations, as it is the paper by Beaulieu and Britton "Rituals for an eclipse possibility in the 8 the year of Cyrus," where lunar phenomena were calculated to fit an interesting text.

Many other applications of the computer to Assyrian-Babylonian astronomy could be investigated, but I believe that everyone will add those specifically apt to her or his own studies.

To finish this talk, I would like to

[12] Graßhoff 1999.

[13] Britton 1999.

mention two cases.

The first is the enormous work made by Neugebauer and van Hoesen for their "Greek Horoscopes,"[14] if we only think that to calculate Jupiter–Saturn conjunction from –60 to +600 they had to use long graphs on tracing paper, which were slided in order to find the periods (every 60 years) and then perform hand calculations by tables: it takes a few minutes (5) to calculate all of them by computer, so one can imagine what amount of time could be saved.

The second is to revive an interesting paper by Otto Neugebauer, in which he studied the influence of Babylonian astronomy to Renaissance art.[15]

Indeed an analysis of the famous tables of the *Trés riches heures du Duc du Berry* (fig. 13) is an example of the limitation of computer applications: no computer will have the talent and the imagination of the Limbourg Brothers to draw those unequalled miniatures, although with a computer one could quickly calculate the *litterae dominicales* (fig. 14), and no computer would have the command of astronomy and culture which lead Neugebauer to find Babylonian influences in such an art masterpiece.

[14] Neugebauer-van Hoesen 1959.

[15] Neugebauer 1974 (Astr. & Hist. 507).

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## FIGURES

1

## III. Astronomische Ausdrücke.

I. Monatsnamen: , Nisannu, Airu, , Simannu, Dûzu, Abu, Ulûlu, Tišritu, Araḫ-samna, Kislimu, Ṭebitu, Šabâṭu, Adaru.

II. Zeitangaben: ûmu, der ganze Tag, urru, Tag, mušu, Nacht, namâru, Aufgang, Morgen, eribu, Untergang, Abend, elâtum, Morgenhimmel, Morgendämmerung, lilâtum, Abendhimmel, Abenddämmerung, mušu ana namâru erste Morgendämmerung; man-du, Solstitium, šuqa-lulu šatti, Aequinoctium.

III. Planetennamen: , Šamaš, Sonne, , Sin, Mond, Gut-tu, Mercur, Dil-bat Venus, Anu, Mars, Te-ut, Jupiter, , Mullalu, Saturn.

IV. Zeichen des Thierkreises: ku, aries; te, , taurus, mâšu, maš-mašu, gemini, nangaru, cancer, a, leo, ki, šerû, virgo; ṣab, nûru (?), libra; , gir, gir-tab, aqrabu, scorpius, pa, arcitenens, šaḫ, šaḫû, caper, gu, amphora, zib, nûnu, pisces.

V. Weltgegenden: u. iltânu Norden, u. , šûtu, Süden, u. , šadû, Osten, u. , aharrû, Westen, — maḫrû, westlich, arkû östlich, eliš, nördlich, šapliš, südlich.

VI. Sternenamen: pidnu, Aldebaran, šarru, Regulus, gar = narkabtu, Wagen, ḫurru, Antares, kak-ban Sirius, absin = šerû, Jungfrau.

7.

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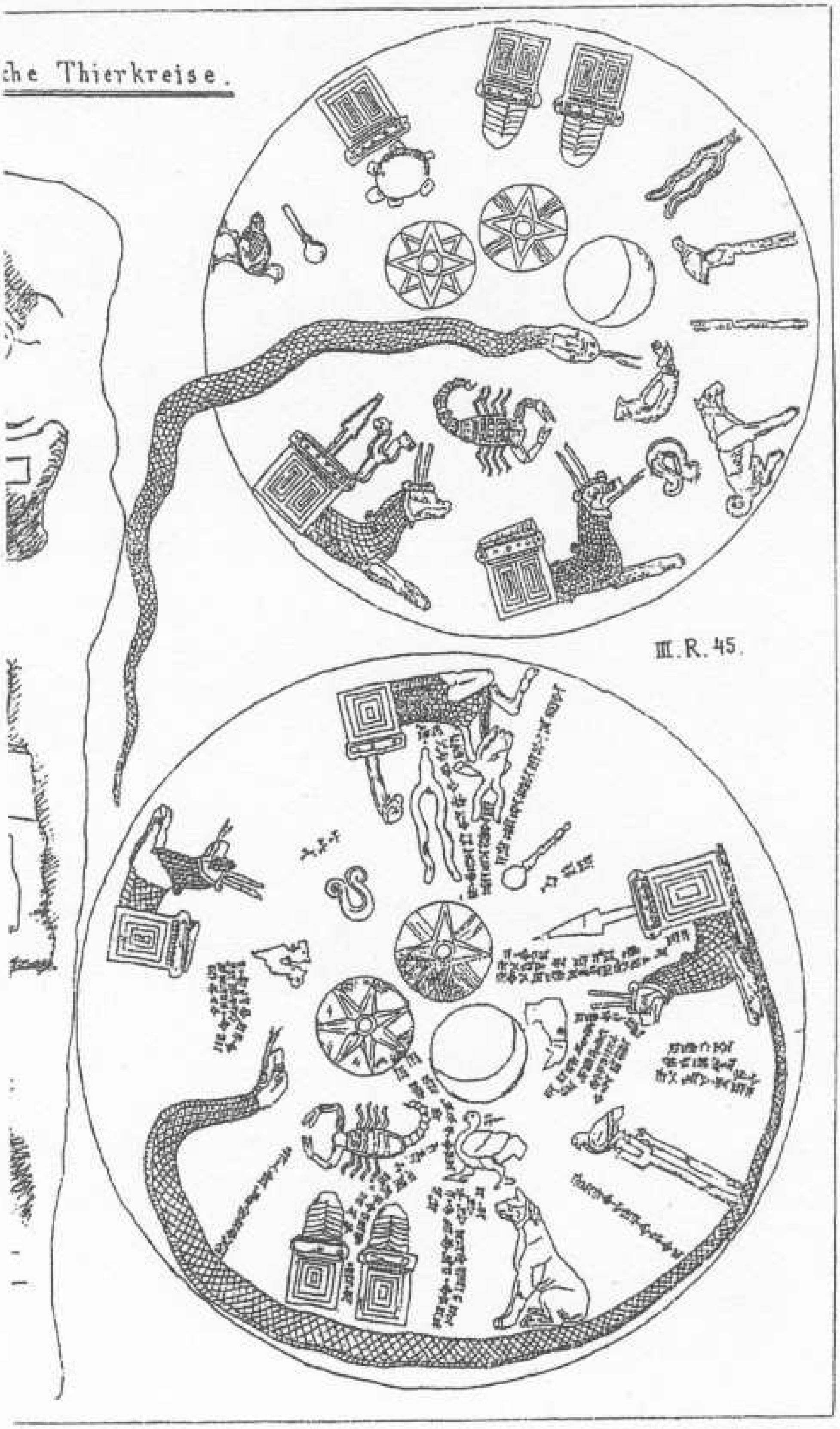
# I. Babylonische Mond-Ephemeride des Jahres 189 SA.

(— 122 bis in — 121 der christlichen Zeitrechnung.)

| Monatsnamen und Datum. | | Zahlenangaben über Mondstellungen. | Datum für ● und ○ (Neu- und Vollmonde) in babylon. Zeit. ($0^h = 6^h$ nach dem babylon. Mittag.) |
|---|---|---|---|
| | | | ● 23. März $2^h$ $21^m$. |
| Nisan | 1 | 20 30 tab | 1. Nisan = 25. März ($45^h8$). |
| " | 12 | 1 10 šu | ○ 6. April $7^h$ $11^m$ = 13 Nisan. |
| " | 13 | 8 40 lal | |
| " | 13 | 9 na | |
| " | 14 | 8 30 mi | |
| " | 26 | 15 mat | |
| 1 N + 29 = 1 I u. 25 M + 29 = 23 A | | | ● 21. April $16^h$ $29^m$ = 28. Nisan. |
| Ijar | 30 | 15 20 | 1. Ijar = 23. April ($32^h$). |
| " | 12 | 4 šu | ○ 5. Mai $15^h$ $44^m$ = 13. Ijar. |
| " | 13 | 14 20 lal | |
| " | 13 | 5 na | |
| " | 14 | 1 40 mi | |
| " | 26 | 17 40 mat | |
| 1 I + 30 = 1 S u. 23 A + 30 = 23 M | | | ● 21. Mai $4^h$ $1^m$ = 29. Ijar. |
| Sivan | 1 | 22 30 tab | 1 Sivan = 23. Mai ($44^h7$). |
| " | 12 | 30 ša šu | ○ 4. Juni $1^h$ $28^m$ = 13. Sivan. |
| " | 13 | 5 lal | |
| " | 13 | 8 30 na | |
| " | 14 | 10 50 mi | |
| " | 26 | 16 10 mat | |
| 1 S + 29 = 1 T u. 23 M + 29 = 21 J | | | ● 19. Juni $13^h$ $42^m$ = 28. Sivan. |
| Thammuz | 30 | 16 40 | 1. Thammuz = 21. Juni ($35^h3$). |
| " | 12 | 11 50 šu | ○ 3. Juli $18^h$ $30^m$ = 13. Thammuz. |
| " | 13 | 12 30 lal | Am Ende des Planetentextes für diesen Monat steht mit Sicherheit am 28. eine Sonnenfinsterniß verzeichnet; sie fand statt am Abend, war aber in Babylon nicht sichtbar. |
| " | 13 | 1 10 na | |
| " | 14 | 1 mi | |
| " | 27 | 16 40 mat | |
| 1 T + 29 = 1 A u. 21 J + 29 = 20 Jl | | | ● 18. Juli $22^h$ $21^m$ = 28. Thammuz ⊙ t. |
| Ab | 30 | 12 30 ina dan | 1. Ab = 20. Juli ($26^h6$). |
| " | 13 | 8 10 šu | ○ 2. August $4^h$ $2^m$ ☾ p! = 14. Ab. |
| " | 14 | 3 20 lal | Im Planetentext steht neben lal deutlich am 14. eine als stattzufindende Mondfinsterniß verzeichnet, die auch für Babylon wirklich sichtbar war. |
| " | 14 | 4 20 na | |
| " | 15 | 8 10 mi | |
| " | 28 | 10 20 mat | |
| 1 A + 30 = 1 El u. 20 Jl + 30 = 19 A | | | ● 17. August $6^h$ $42^m$ = 29. Ab. |

Zu S. 150.

3



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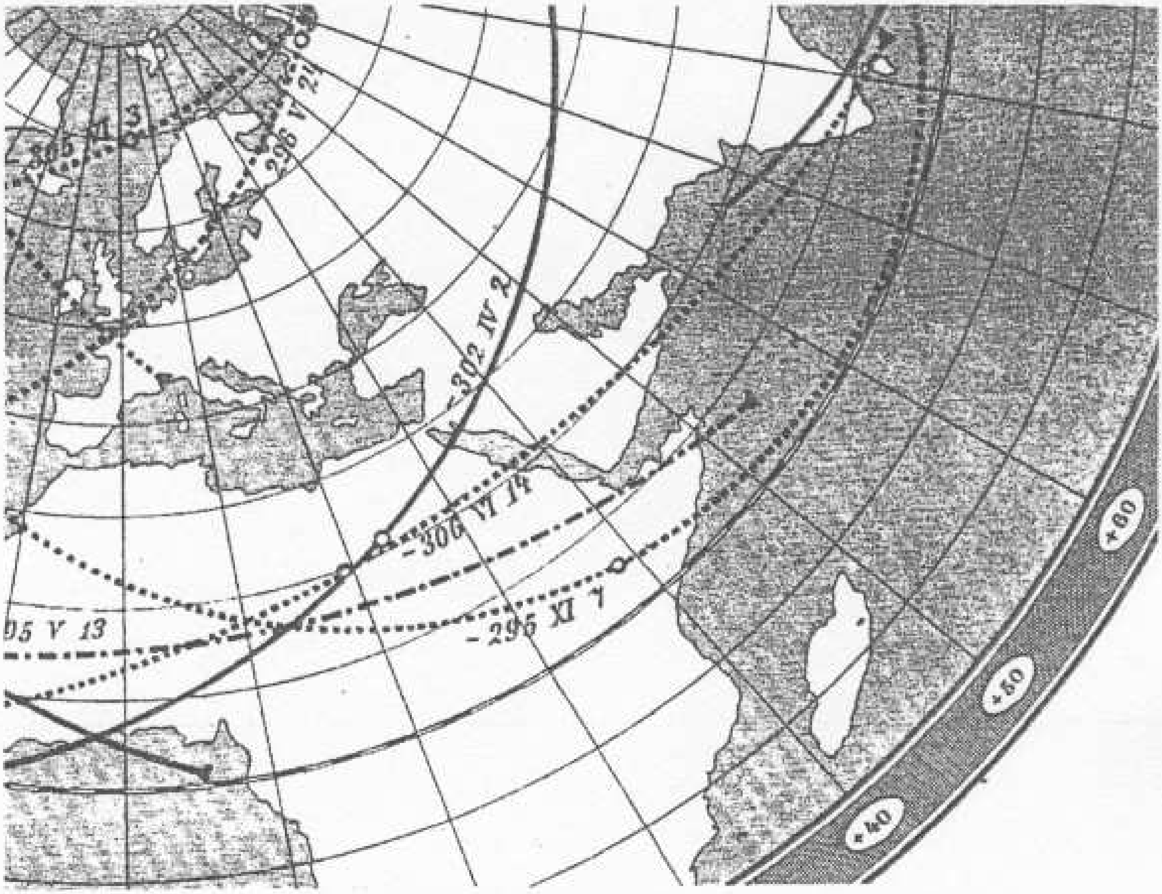


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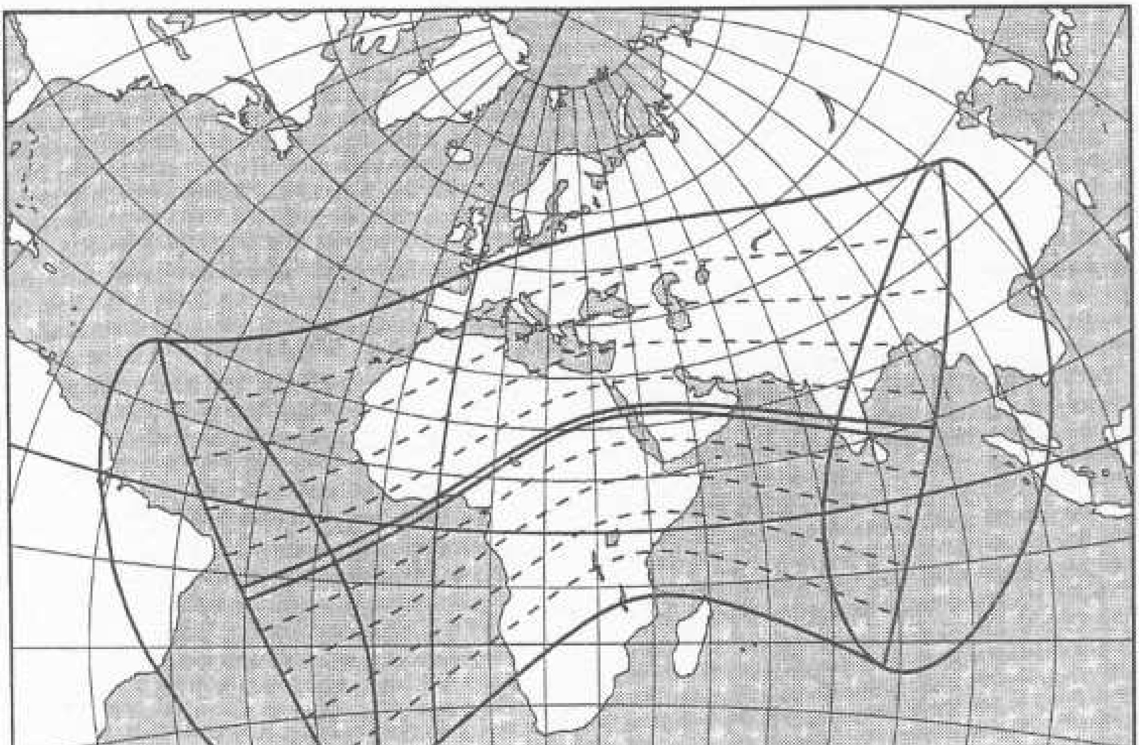
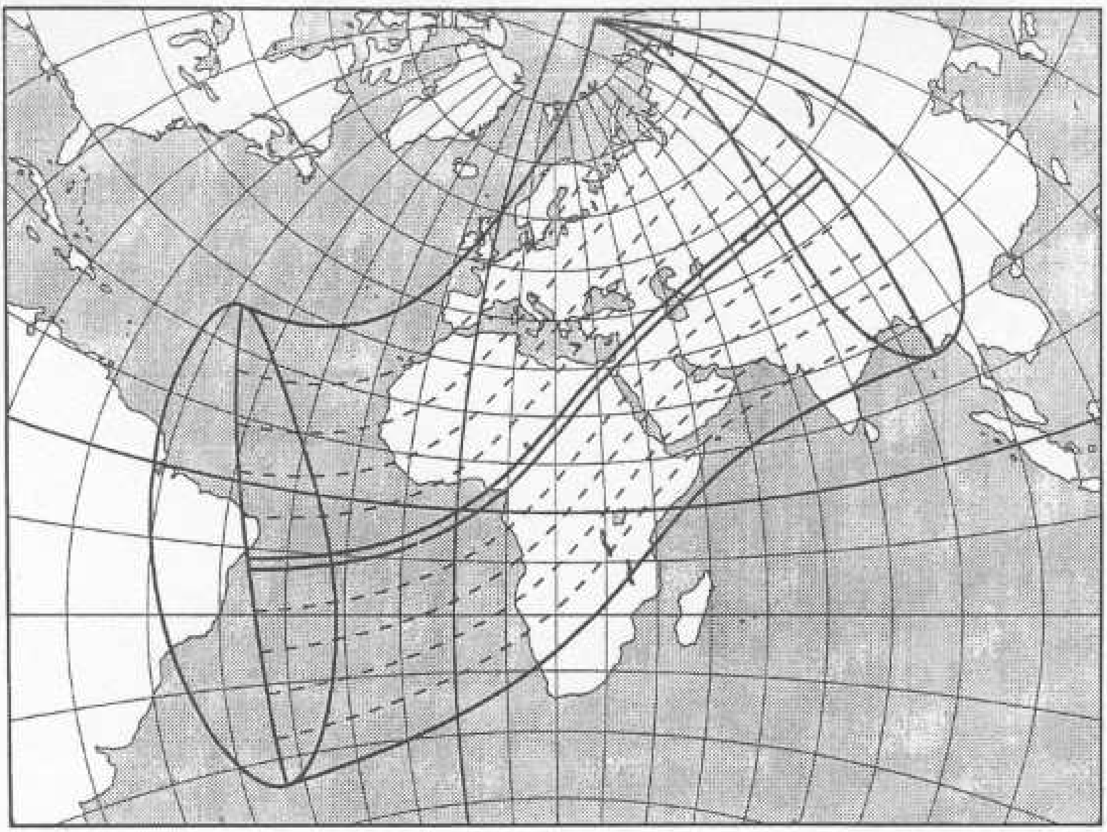
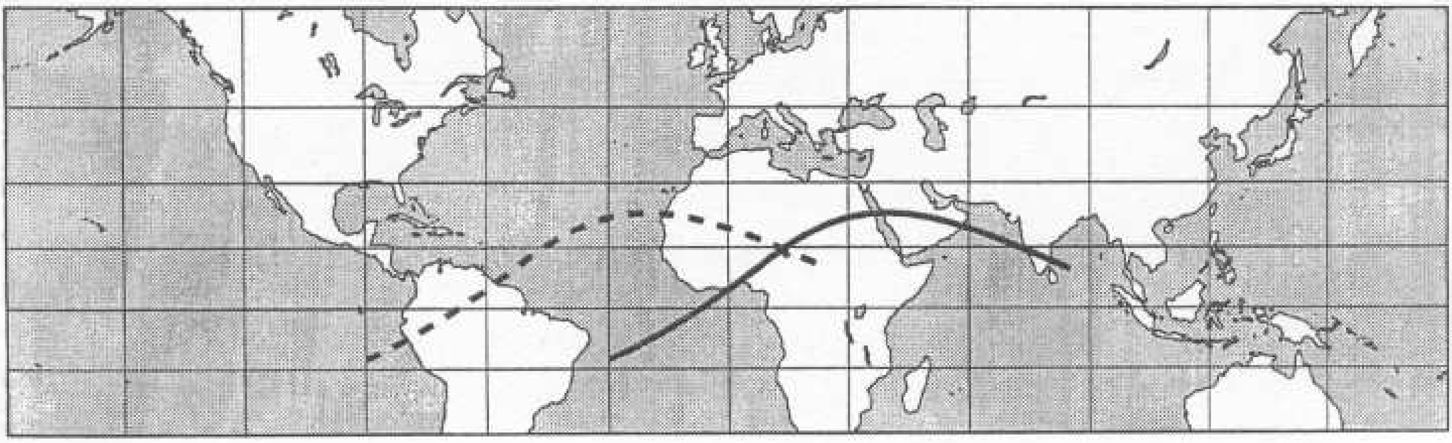


Annular solar eclipse -306 June 14

6



Total solar eclipse -302 April 2



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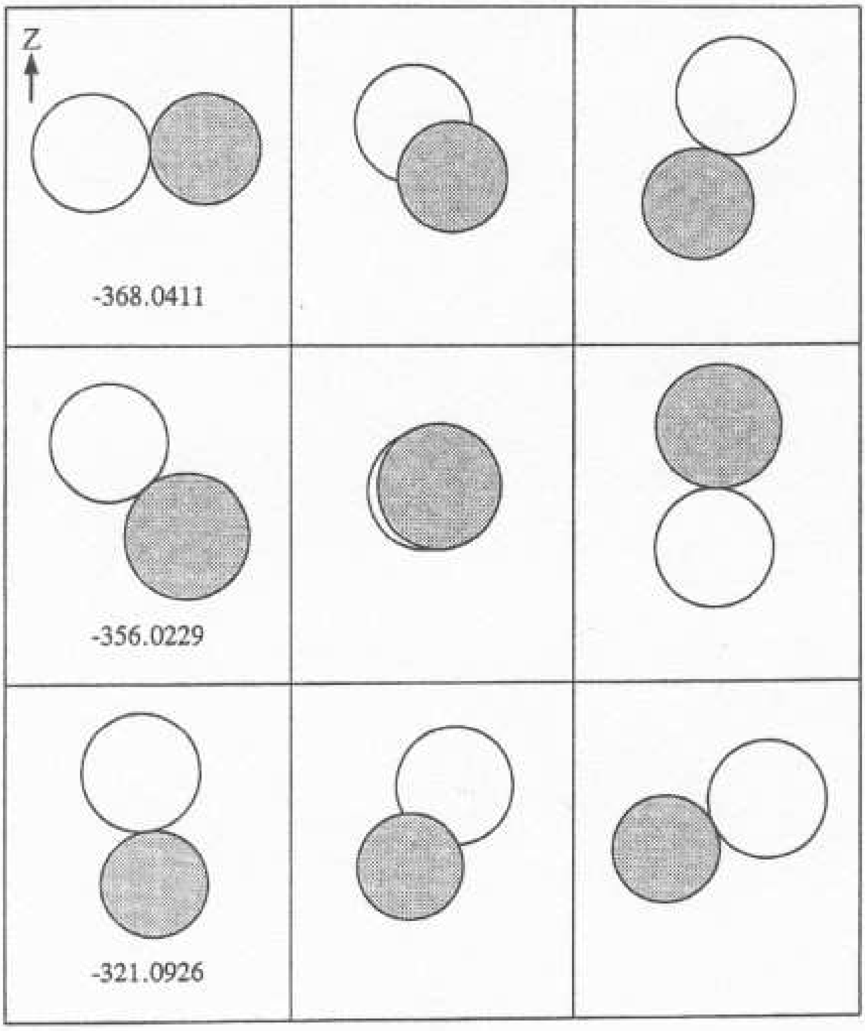


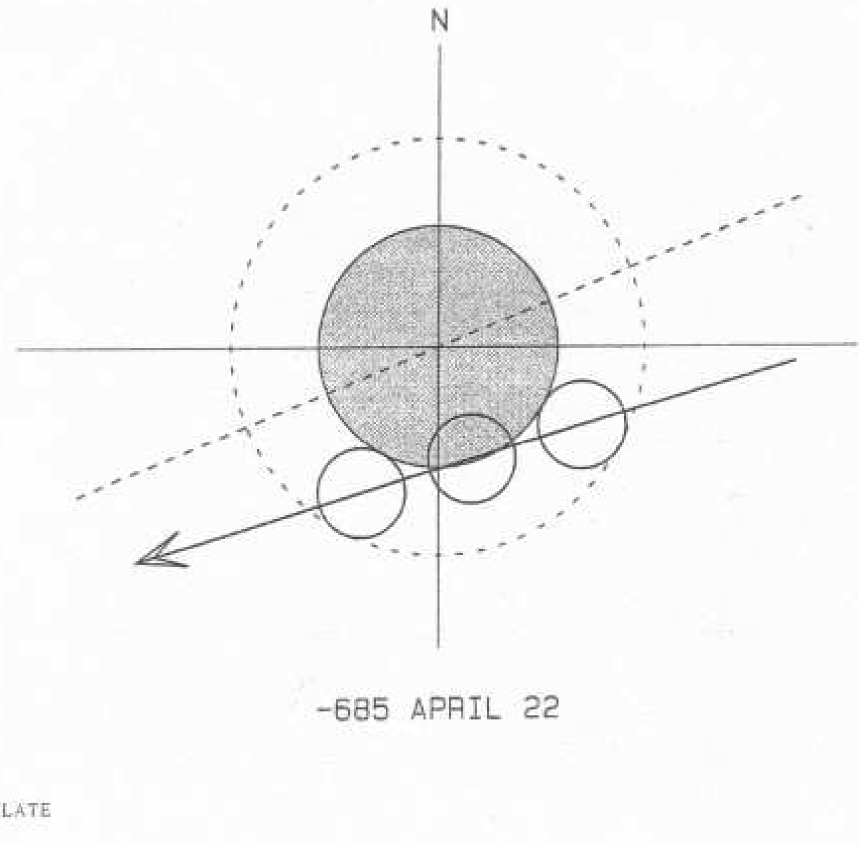

Wind:

gusty South

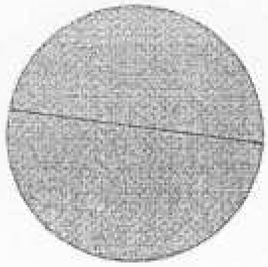
South

gusty North-West

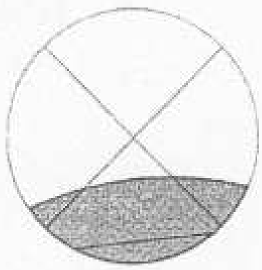
9




-685 APRIL 22



*-662 August 3*



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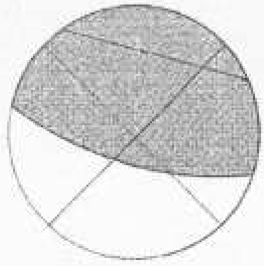
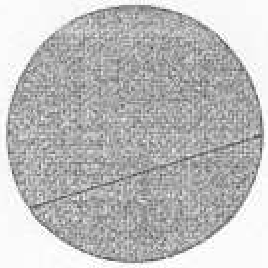
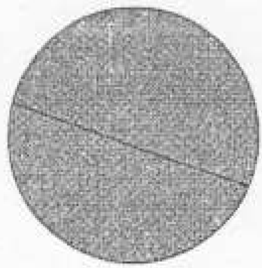


*-660 December 6*



*-659 June 1/2*



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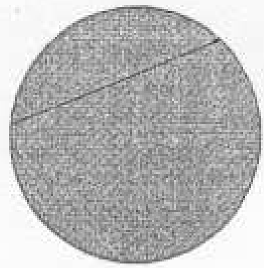

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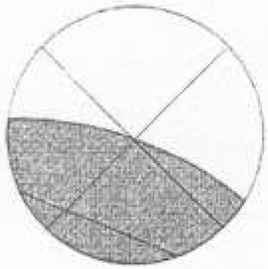
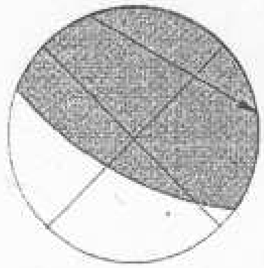
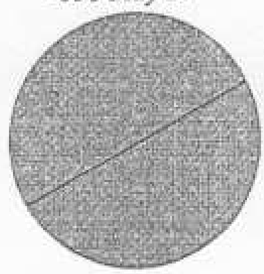


*-658 November 14/15*



*-656 September 24*



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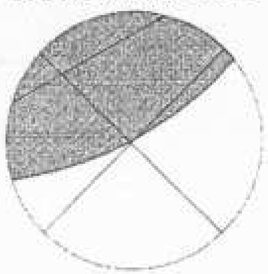
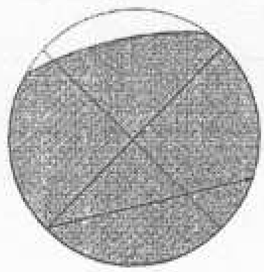
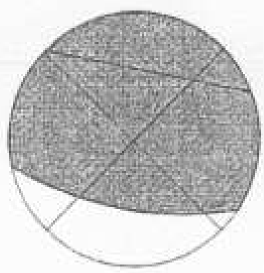


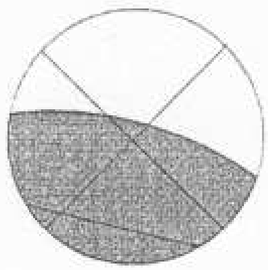
*-654 March 9/10*



*-652 January 19*



*-652 July 12/13*



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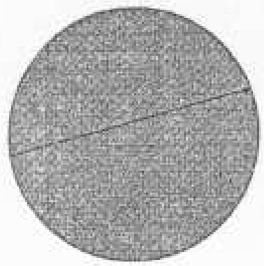
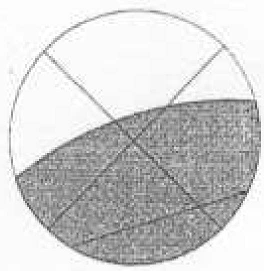


*-648 May 2*



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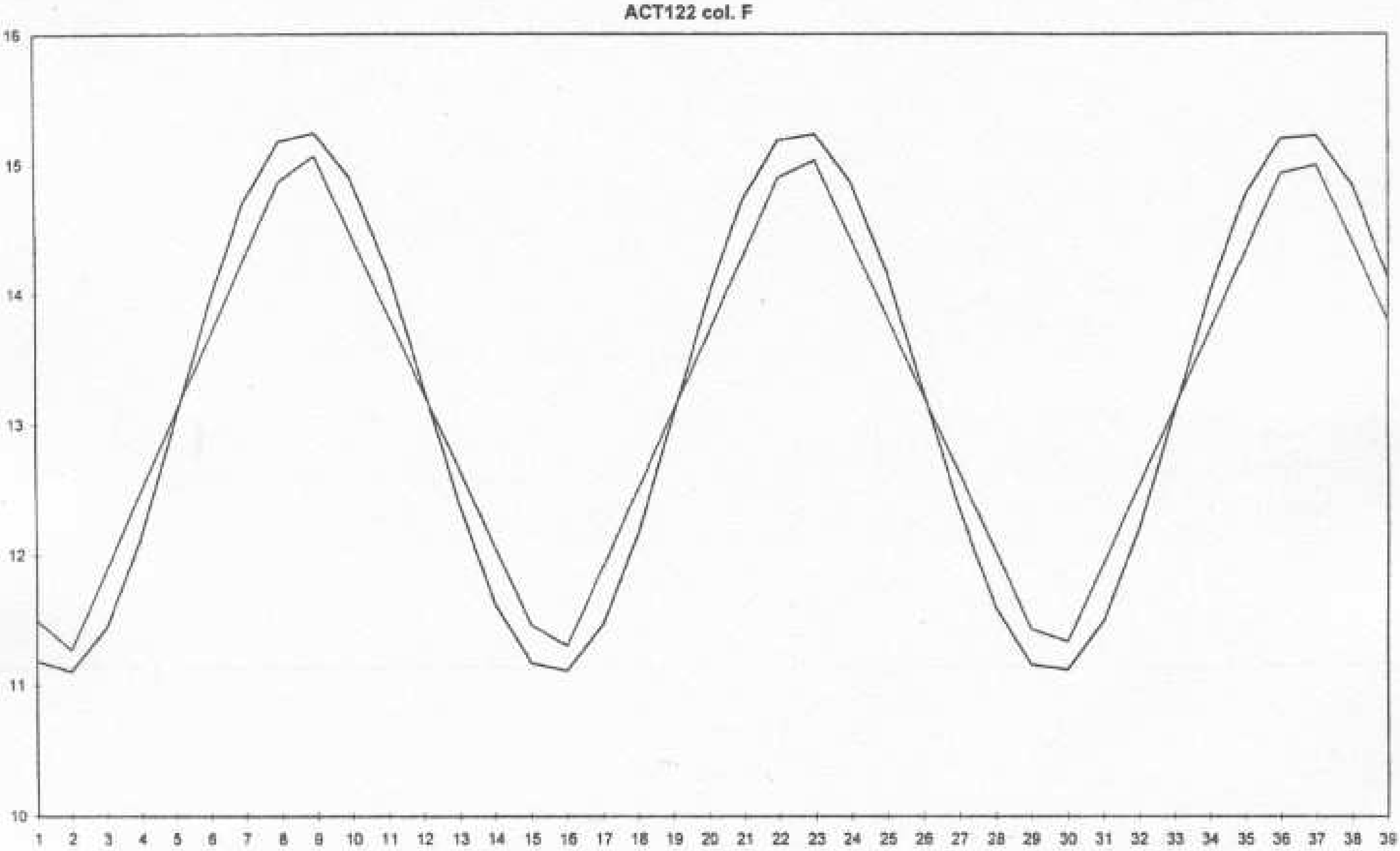


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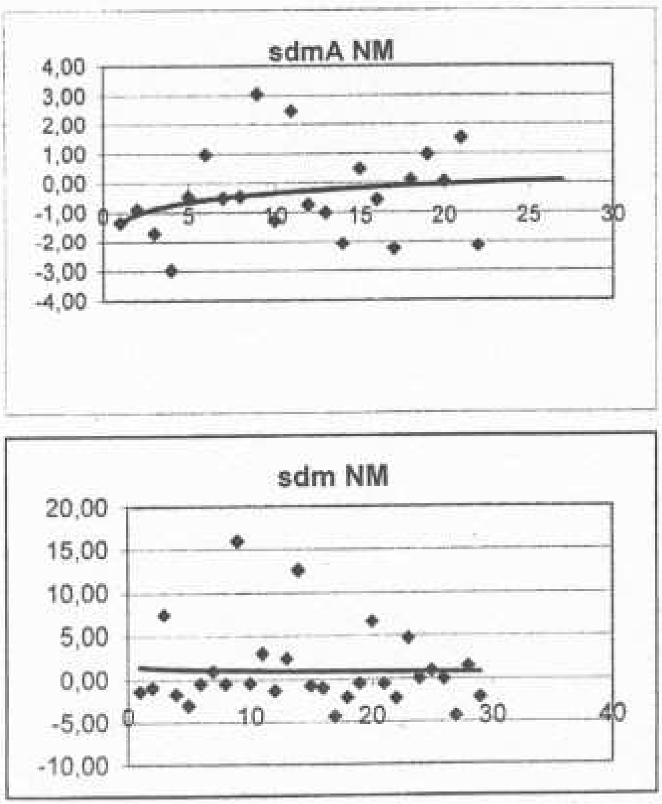


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| | NMoon |
|---|---|
| sdmA NM | sdm NM |
| -1,35 | -1,35 |
| -0,90 | -0,90 |
| -1,70 | 7,50 |
| -2,97 | -1,70 |
| -0,47 | -2,97 |
| 0,98 | -0,47 |
| -0,52 | 0,98 |
| -0,48 | -0,52 |
| 3,05 | 15,97 |
| -1,28 | -0,48 |
| 2,48 | 3,05 |
| -0,75 | -1,28 |
| -1,02 | 2,48 |
| -2,08 | 12,57 |
| 0,48 | -0,75 |
| -0,58 | -1,02 |
| -2,27 | -4,33 |
| 0,10 | -2,08 |
| 0,97 | -0,48 |
| 0,02 | 6,63 |
| 1,53 | -0,58 |
| -2,17 | -2,27 |
| | 4,68 |
| | 0,10 |
| | 0,97 |
| | 0,02 |
| | -4,30 |
| | 1,53 |
| | -2,17 |

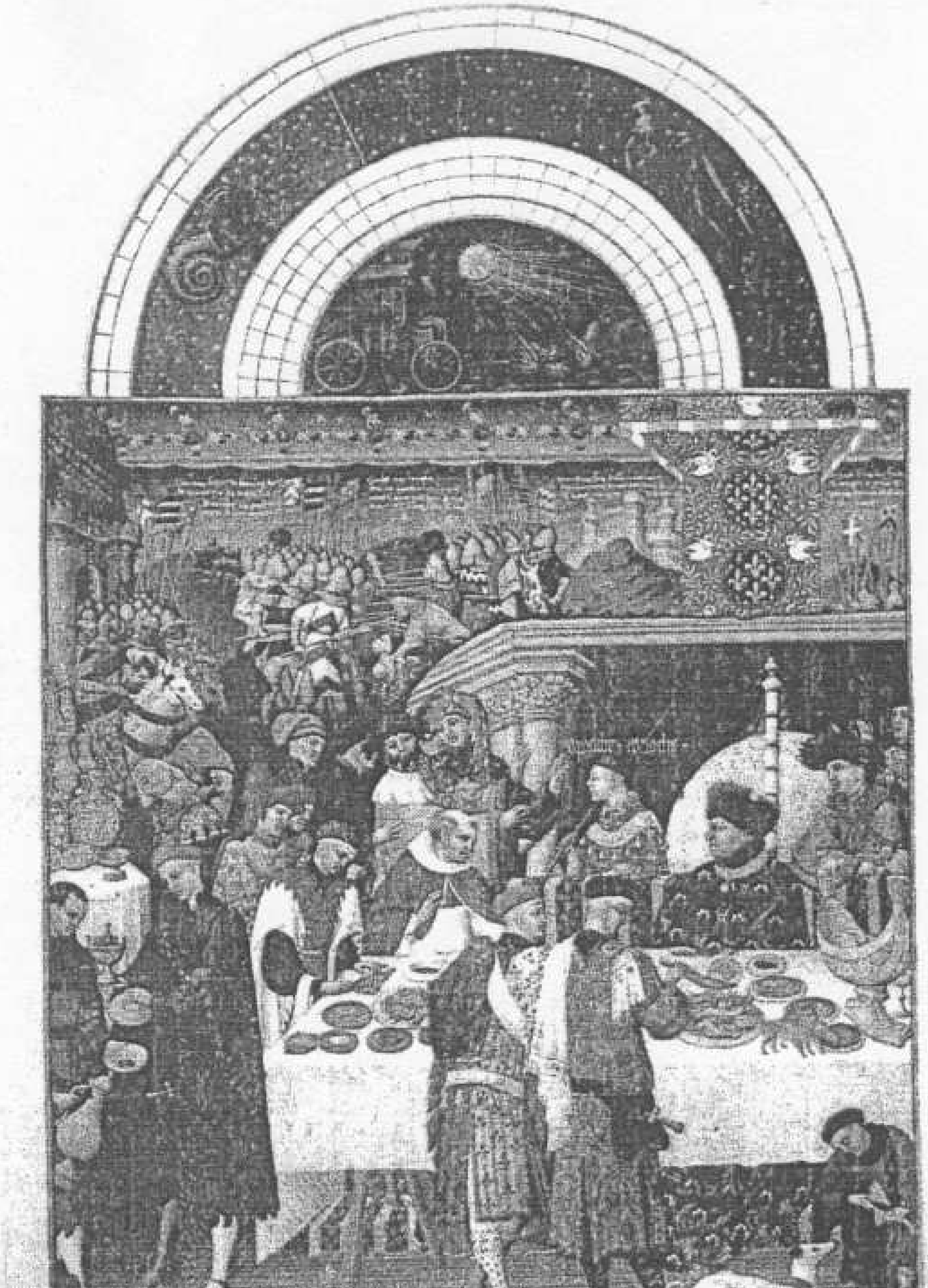

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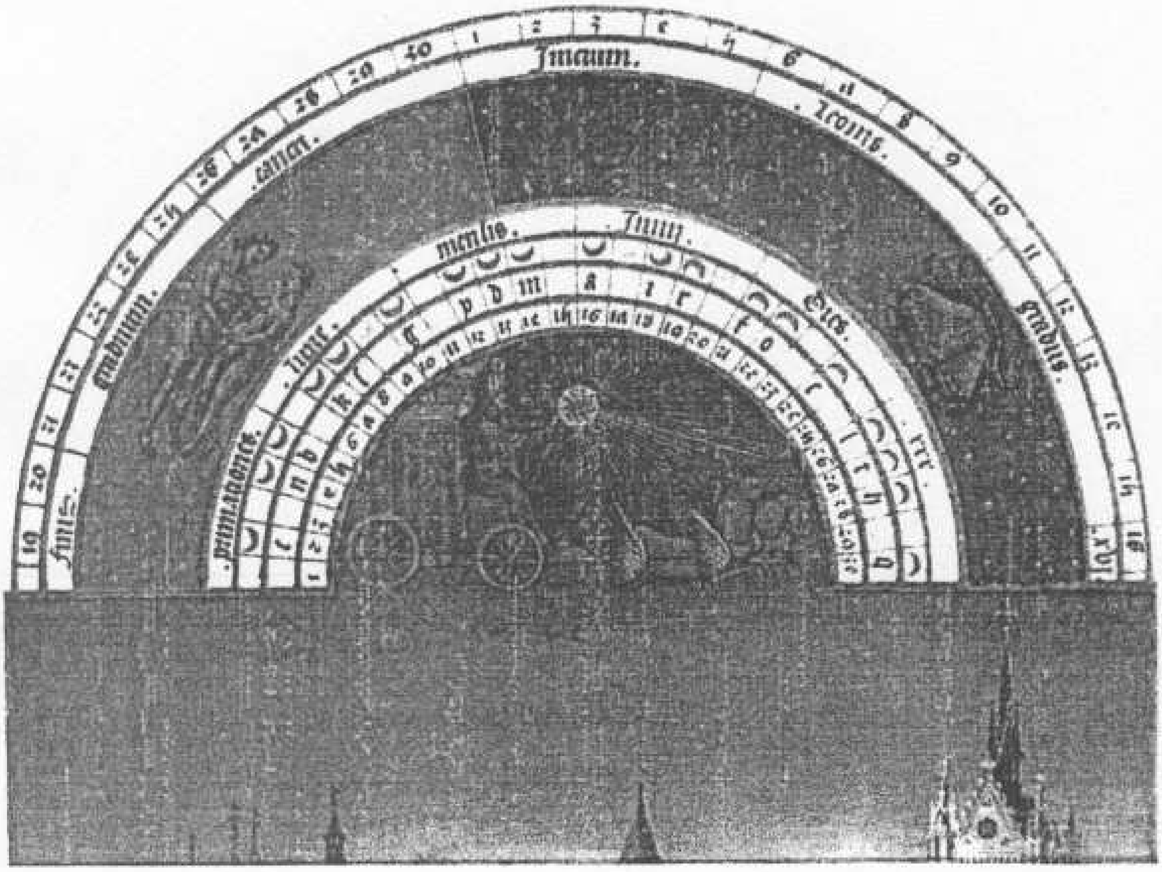
PLATE XV



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