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1490. ASTRONOMICAL TEXT: TREATISE ON SOLAR MODELS AND TABLES

inv. 515 Tav. XXIX
Oxyrhynchos (cm 5,5 × 25) II^{p}

Ed. pr.: M. Manfredi, *Presentazione di un testo astronomico e discussione di un documento di Antinoe*, in *Atti dell'XI Congresso Internazionale di Papirologia. Milano 2-8 Settembre 1965*, Milano 1966, p. 237-248 [LDAB 4662; *Comunicazioni* 5, pp. 68-69].

Bibl.: D. Baccani, *Oroscopi greci. Documentazione papirologica*, Messina 1992, p. 36, n. 6; Jones, *Astronomical Papyri*, I, p. 306-307; Id., *Studies in the Astronomy of the Roman Period IV: Solar Tables Based on a Non-Hipparchian Model*, *Centaurus* 42 (2000), p. 77-88; Id., *An* Almagest *Before Ptolemy's?*, in C. Burnett, J. P. Hogendijk, K. Plofker, and M. Yano, eds., *Studies in the History of the Exact Sciences in Honour of David Pingree*, Leiden 2004, p. 129-136.

The present text is one of the very few known papyri deriving from a theoretical work on astronomy, and in spite of obscurities arising from its less than ideal state of preservation, it is of exceptional historical interest as a witness to astronomical models and tables from the period of Greek astronomy immediately before Ptolemy.

The papyrus preserves the full height of a column of text from a roll, with column width about 7 cm (roughly 25 letters) and approximately 3.5 cm margin at both top and bottom. The text is written along the fibres in an informal bookhand belonging to the first half of the second century. The same hand copied P.Oxy.Astr. 4133, a theoretical astronomical text concerning observations of Jupiter, one of which was made by the author (tentatively identified as Menelaus of Alexandria) on the night of December 31, A.D. 104. A third astronomical papyrus in the same hand is P.Oxy.Astr. 4134, a text whose contents discuss numerical computations that have so far defied interpretation. Very likely all three fragments come from the same roll and treatise; if so, the treatise dealt with a wide range of astronomical problems involving more than one heavenly body. Even if the papyri derive from different rolls, it is practically certain that the present one was found at Oxyrhynchos since the probability of manuscripts in the same hand being found at different sites is exiguous. In common with P.Oxy.Astr. 4133, the upper margin contains traces of three lines of jottings in a third-century cursive that apparently have nothing to do with the astronomical text; in the lower margin is a bit of one further line, perhaps in the same hand. On the back, the other way up, are nearly illegible remains of cursive writing of the early third century, apparently records of receipts. P.Oxy.Astr. 4133 has what might be a column number, 14, centred above the text; if the traces at the edge of a break in a similar position above our present text are likewise a column number, its first letter would appear to be nu, thus a number in the 50s.

Astronomical commentary

Two passages of the text are comparatively well preserved. In the opening lines (at least down to line 7) the author is giving instructions for computing the entries in a table of mean motions for a heavenly body, that is, the uniform circular motions of the components of the assumed kinematic model. In the passage beginning in line 20, the author is discussing the anomaly of the sun, that is, its apparently nonuniform motion as seen from the earth, with reference to an assumed eccentric or epicyclic model, apparently leading into instructions for constructing a table for calculating this anomalistic motion. These passages serve roughly the same function as Ptolemy, *Almagest* 3.1, in the last part of which Ptolemy explains the construction of the solar mean motion table that follows as *Almagest* 3.2, and *Almagest* 3.5, in which he discusses the calculation of the table of the sun's anomaly that follows as *Almagest* 3.6. It is a matter of some interest that the basic principle of Ptolemy's tables, that is, the separation of mean motions and anomaly into distinct tables, is present in this work dating from several decades before Ptolemy. But where Ptolemy's mean motion tables are laid out using divisions of time based on the unreformed Egyptian calendar, with its constant years of 365 days, the corresponding table here was based on the reformed Egyptian calendar, in which an intercalary day was added at the end of every fourth year. Moreover, Ptolemy's mean motion tables record *relative* mean motion since epoch, whereas this table contained the actual positions of the various parts of the model on specific dates.

(marg. cm 3,8)

μεν ρ̅ν̅ϛ̅ κ̅η̅ [ ] κ̅γ̅, βάθ[ουϲ δὲ
ν̅α̅ ι̅ζ̅ ζ̅ μ̅δ̅, π[λ]ạτọụϲ δὲ σ̅λ̅α̣̅ . [
ταῦτα πάλιν ẹκθέμενοι [εἰϲ τὸν
δεύτ̣ερον ϲτίχον τῆϲ [α΄ τρια-
κ̣[ο]νθημέρο̣υ̣ κατάξομ̣[εν ἄλ-
[λο]υϲ κ̅θ̅ ϲτίχουϲ καὶ τωṿ[
] . τ̣ε̣[λ]ει μιᾶϲ τετραετηρί[δοϲ
] . π̣ρ̣οϲαγα̣[γ]όντεϲ̣ δ̣η̣λ̣[
ἄ]λ̣λ̣ην ὁ δη̣[. .]ου δρόμ[οϲ
] μὲν μ̅δ̅ [ ] . κ̣̅α̣̅
]λ̅η̅ μ̅η̅ κ̣[
] . . . . [
]ε̣ν̣τα̣ξ[
. . . .]υ̣ϲ δὲ σ̅ϙ̅δ̅ λ̅ε̣̅ [
φαν]ε̣ρ̣ὸν ὡϲ καὶ τ . [
. . . .]ϲ̣εωϲ τὴν μ . [
πραγ]μ̣ατείαϲ ἔξω τ̣[
. . . . .] ἀ̣νωμαλίαϲ δ[

. . . . .]μ̣εθα κατὰ τὸν̣ [
. . . . .] τρόπον. ὁ ἥλιο̣[ϲ
ὑποθέϲ]εωϲ ἐφ’ ἑκατέ̣[ραϲ
. . . α]ὔ̣ξει τε καὶ με̣[ιοῦτα]ι̣ [
τὴν κεί]ν̣ηϲιν μοίραι̣ϲ δυϲ[ὶν καὶ
τριτ]ημορίῳ ἐάν τε κατὰ ἔ̣[κκεν-
τρον] κ̣είμενοϲ φέρηται ἐάν τ[ε κατ’ ἐ-
πικύ]κλου. τοῦτο̣ γὰρ ἡμῖν̣ ἐν̣ τ̣[ῷ περὶ
τῆϲ] ἀνωμαλίαϲ τοῦ ἡλίου δ̣έ̣δ̣[εικ-
τα]ι̣. ἐ̣πεὶ οὖν δυϲὶν μοίραιϲ κα[ὶ τρι-
τη]μορίῳ τὸ διάφορόν ἐϲτιν [
. .] . τηϲ κεινήϲεωϲ προϲεθ[
.]κ̣ τοῦ τεταρτημορίου . [
.] . τρεῖϲ μοίραϲ. ο̣ὐ̣ γὰρ [
.]ο̣ν̣ε̣ . [. .] δύο εἰϲ . . . . . [
.] . . [ ]ειϲ̣ . . [ ] . . . [
]αι̣επ̣ . [ ] . . . τω̣[
] ὡ̣ϲ ἀπεδε̣[ί]ξα̣[μεν
]ε̣ϲα παρο̣[
]κύκλιο̣ν̣[
] . κωϲ´ ϲ̣⟦ων⟧ ὑποτ̣[
] ἔ̣γγιϲτα δύο πε̣μ̣[
φαν]ε̣ρὸν ὡϲ ἐὰν μ̣[
]των δύο πέμπ̣[των
γιν]ο[ι]τ̣ο ἂν ἑξηκ[οϲτὰ
] . λ̣ει τῶν $\overline{β}$ κδ . [
] . ο̣ν εἶναι με . [
] . ν αὔξην ἀνω[
(marg. cm 3,6)

[... in longitude] 156;28,[xx],23, and in depth
51;17,7,44, and in latitude 231;x[x,xx,xx.]
Again we set out these [in the]
second row of the [thirty-]
day (column) and we extrapolate [the]
remaining 29 rows and...
the end (?) of one four-year period
...prolonging...
another (?) the ... course
... 44;[xx,x]x,21...
[...] 38,48,2[x...]

...
...
... 294;35,[xx,xx...]
Obviously also...
...
procedure (?) outside...
... anomaly ...
we [...] in the established
manner. [For] the sun
according to either model...
increases and decreases [its]
motion by two degrees [and]
[an *x*th] part, whether
it travels situated on an eccentre or
on an epicycle. For we
have proved this in the (section) on the sun.
So since by two degrees and [an *x*th]
part the difference is...
its motion, (we?) add...
... the fourth part...
... three degrees. For not...
... two into...
...
...
... as we have demonstrated
...
... circular (?)...
...
... approximately two fifths (?)...
... sixtieths (?)...
... of the 2;24 (?)...
... to be...
... augment...

1-2. In Greek astronomy the apparent motion of a heavenly body was characterized by three components, conventionally designated as motion in μῆκοϲ ("length" or longitude), πλάτοϲ ("breadth" or latitude), and βάθοϲ ("depth"). Longitudinal motion is motion along the ecliptic circle, while latitude and depth are the body's deviation north and south of the ecliptic and its varying distance from the earth. The nomenclature is attested as early as the Keskintos Inscription (*IG* 12.1, 913, *c.* 100 B.C.) and was common in the Roman period, although in all Ptolemy's works except the *Harmonics* the term "depth" is eschewed in favour of "anomaly" (ἀνωμαλία). Cf. O. Neugebauer, *A History of Ancient Mathematical Astronomy*, Berlin 1975, v. 2, 933; A. Jones, *Ptolemy's First Commentator*, TAPhS 80.7 (1990), p. 54-55; Jones, "The Keskintos Astronomical Inscription: Texts and Interpretations," *SCIAMVS* 7 (2006), pp. 3-41, esp. 16-19.

With each of these three aspects of celestial motion **1490**, 1-2 associates a number written as a whole number and (apparently) three sexagesimal fractional places. The magnitude and precision of these numbers show that they are to be interpreted as mean positions in longitude, anomaly, and latitude expressed in degrees, that is, (1) the number of degrees along the ecliptic from a longitudinally fixed reference point of the ecliptic, normally the vernal equinoctial point at Aries 0°, to the mean position of the body (i.e. disregarding anomaly); (2) the number of degrees along the ecliptic from a limiting point of the body's anomalistic motion, typically its apogee, to its mean position; and (3) the number of degrees along the ecliptic from a limiting point of the body's latitudinal motion, typically its northern limit, to its mean position.

According to the theories of Ptolemy's *Almagest*, the planets have sidereally fixed apogees and northern limits, while the sun has a tropically fixed apogee and no latitudinal component in its motion whatsoever. The only body in Ptolemy's system that has independent mean motions of all three varieties is the moon. Hence in the previous publication of **1490** Manfredi hypothesized that the first lines of the papyrus concern the moon. One can, however, point to Greek astronomical texts both before and after Ptolemy that attribute periodic motion in "length," "depth," and "breadth" to other heavenly bodies. The Keskintos Inscription contains a tabular list of periods of all three kinds (and additionally periods κατὰ cχῆμα, which are synodic periods, i.e. motion relative to the sun) for at least four of the five planets. Theon of Smyrna (ed. Hiller, p. 172) mentions a theory of the sun's motion according to which it has a latitudinal deviation from the ecliptic, and distinct periods of 365 1/4 days ("length"), 365 1/2 days ("depth"), and 365 1/8 days ("breadth"). Moreover, Theon's solar periods were the basis for a table of solar mean motions of all three kinds preserved in P.Oxy.Astr. 4174a (*c.* A.D. 200). Thus the object to which **1490**'s first lines refers cannot be identified purely from the terminology. *Prima facie* the most likely candidate should be the sun, since this is known to be the subject of the later lines of the papyrus (cf. line 27).

3-7. Mention of cτίχοι, "rows," in 4 and 6 show that the text is describing a method of constructing a numerical table, of which the numbers in 1-2 constitute the second row. The part of the table initially under discussion comprised at least three columns (for the three varieties of mean position) and thirty rows standing for an interval of thirty days (restoring τριακονθημέρου in 4-5 in the light of the numeral 29 in line 6). Since these are mean, that is, uniformly increasing, positions, each line would be obtained by adding appropriate constants for the daily progress to whatever values stood in the first line.

Ptolemy's mean motion tables, for example the table of the moon's mean motions in *Almagest* 4.4, do not refer to specific dates but tabulate *progress* in each kind of mean motion over a given time interval; each column starts with zero degrees progress for zero elapsed time. The table described in **1490**, on the other hand, must have contained actual positions for specific dates, since the numbers to be written in the second line are far too large to be one or two days' progress of any kind for any of the heavenly bodies. Another important difference with respect to Ptolemy's mean motion tables is indicated by the reference to a "four-year interval" (τετραετηρίc) in 7. Ptolemy's tables measure time in 30-day Egyptian months and, on the longer scale, in constant "old" Egyptian years of 365 days. The table of 1490 must have been structured on the reformed Egyptian calendar which had an additional day at the end of every fourth year. Apparently the author has it in mind to prolong the table for at least the four years of a calendrical cycle, which would amount to 1461 lines. This would have resembled an ephemeris more than Ptolemy's tables, though the extant examples of ephemerides consist only of true positions, not mean; cf. Jones, *Astronomical Papyri*, I, p. 40-42.

The second row of the table ought thus to have referred to the second day of the first month of some Egyptian calendar year, that is, Thoth 2 (August 30 or 31). Now if one uses Ptolemy's solar mean motion table (*Almagest* 3.2) to calculate the sun's mean position in longitude for Thoth 2 (reformed calendar) of any year within many decades of A.D. 100, one obtains a result within a degree of the 156° 28' recorded in the papyrus; for example for noon of Thoth 2 (August 30) in A.D. 100 one finds 156° 22'. Since the solar theory of the papyrus was clearly not Ptolemy's, exact agreement cannot be expected, but the closeness is remarkable and strongly supports identifying the subject of the papyrus' table as the sun. (Venus or Mercury would also be possible, though less likely, since the mean longitude of either planet coincides with the mean sun.)

8-17. Too little remains of these lines to indicate even the general drift of the text. In 9, δρόμοϲ could signify either a rate of motion or a position. The numerals in 11-12 appear to belong to a second list of mean positions, the relationship of which to those in 1-2 is obscure. Those in 14 may be from yet a third set. Perhaps more than one heavenly body is involved.

18-20. Since in the terminology of the papyrus βάθοϲ designates the mean motion with respect to which the heavenly body makes its variation in distance from the earth, and hence its variation in apparent velocity, ἀνωμαλία must mean the variation in apparent velocity itself, and the consequent deviation of the body's apparent position from its mean position. Although not enough text survives in these lines for a restoration of continuous text, the probable sense would have been along the lines of τὸ τῆϲ ἀνωμαλίαϲ διάφορον ἐκθηϲόμεθα κατὰ τὸν ὑπογεγραμμένον τρόπον, "we obtain the difference due to the anomaly by the method set out below."

20-28. For the restorations in 21 and 24-26 cf. Theon of Smyrna (ed. Hiller, 166): ἀλλ' ὅτι μὲν καθ' ἑκατέραν τὴν ὑπόθεϲιν, τὴν κατ' ἔκκεντρον καὶ τὴν κατ' ἐπικύκλον, ϲῴζεται τὰ φαινόμενα, δείκνυϲιν ἐκ τούτων, and Ptolemy, *Almagest* 3.4 (ed. Heiberg, 1.232): προϋποληπτέον καὶ τὴν περὶ τὸν ἥλιον φαινομένην ἀνωμαλίαν... δύναϲθαι μὲν καὶ δι' ἑκατέραϲ τῶν προκειμένων ὑποθέϲεων [scil. τῆϲ κατ' ἐπίκυκλον καὶ τῆϲ κατ' ἔκκεντρον] ἀποτελεῖϲθαι. Both Theon and Ptolemy make it clear that the applicability of the epicyclic and eccentric models (ὑποθέϲειϲ) to the sun's anomalistic motion, as well as their functional equivalence, was known to Hipparchus in the second century B.C.

According to 26-28, the author of our text devoted either a separate monograph or a section of the present treatise to the sun's anomaly, demonstrating that, regardless of which model is assumed, the sun "increases and decreases its motion" by two and a fraction degrees; the space available in the gaps of both 23-24 and 28-29 are too short for the fraction to have been anything except one third. The only plausible meaning that an "increase" or "decrease" of 2 1/3 degrees (2° 20') in the sun's "motion" could have is that this is the sun's maximum equation, i.e. the furthest that it can be in longitude east or west of its mean position. The author's lost discussion must have been analogous to Ptolemy's treatment of the topic (for the eccentric model only) in *Almagest* 3.4. Ptolemy starts out with three observations providing the longitude of the sun on specific dates – his observations are two equinoxes and a summer solstice – and from these he deduces that if the sun revolves uniformly on an eccentric circular path around the earth, the distance between the earth's centre and the centre of the sun's path is 1/24 of the path's radius. This eccentricity results in a maximum equation of approximately 2° 23'. The same maximum equation would have resulted if the same observations had served to calibrate an epicyclic model. Our text's maximum equation is very close to Ptolemy's, and it is possible that the discrepancy arose through inexact calculations rather than a different empirical basis,

28-46. The remaining lines of the column probably described arithmetical procedures for deriving a table of solar anomaly from the maximum equation that has just been stated twice. On analogy with Ptolemy's solar anomaly table in *Almagest* 3.6, this table would likely have used the mean position in anomaly ("depth") as an index against which was tabulated the corresponding values of the solar equation, which would be added to or subtracted from the mean position in "length" to obtain the sun's true longitude for a given date. Unfortunately all details of this very broken part of the text are obscure and subject to only very tentative interpretations.

29. Does τὸ διάφορον signify the maximum equation itself, in which case the function of the dative case of the preceding words is unclear, or another difference or increment derived from the maximum equation?

30. Perhaps προcεθήκαμεν, "we added."

31. τεταρτημορίου seems likely to refer to a quadrant of a circle here. If the solar equation from an epicyclic or eccentric model is represented as a tabulated function of mean position in anomaly reckoned as elongation from the solar apogee (as in Ptolemy's table), the equation corresponding to 0° and 180° is zero, while the maximum equation corresponds to a mean position of anomaly equal to 90° plus the maximum equation, and again to a position equal to 270° minus the maximum equation. Hence if the maximum equation is 2° 20', this maximum occurs when the mean position in anomaly is either 92° 20' or 267° 40'. It is plausible, however, that some ancient anomaly tables might have set the maxima precisely at the quadrants, 90° and 270° – this would explain why Ptolemy makes an issue of demonstrating the correct locations of the maxima in *Almagest* 3.4. If that is what our text was prescribing, the solar equations cannot have been calculated according to the correct trigonometrical formula representing the assumed model's behaviour.

32. One possible meaning of the "three degrees" would be as the interval at which the argument of the anomaly table was tabulated; in Ptolemy's anomaly table the intervals are 6° for the two quadrants near the apogee, and 3° for the remaining quadrants.

38. Perhaps ἡμικύκλιον, "semicircle," e.g. forming part of an explanation of the fact that the equation is to be subtracted from the mean position in longitude when the mean position in anomaly is less than 180°, but added in the remaining semicircle.

39. ων is deleted by crossing out; κωc is written above the line in smaller letters but likely the same hand as the main text.

40. The two fifths mentioned here and in 42 have no obvious relation to the maximum equation discussed previously. Conceivably this might be a value for the maximum solar latitude, which is given as half a degree in other Greek sources that assume such a concept; see Neugebauer, *History*, v. 2, 629-630.

44. If κδ is a numeral – and there is no other obvious interpretation – one would expect a stroke above it. 24 might be a representation of two fifths as a sexagesimal fraction.

46. αὔξην likely means "increment," as in a table containing quantities that increase by constant differences. αὔξη is much rarer than its synonym αὔξηcιc, and characteristic of Plato (though not in any sense plausible here).

1491. ASTRONOMICAL TEXT: DESCRIPTION OF A LUNAR SYZYGY-TABLE

inv. 2414 Tav. XXIX
? (cm 7 × 16) II^{P}

Bibl.: Neugebauer, *Astronomical Papyri*, pp. 383-391; Id., *History*, p. 946; A. Jones, *A Greek Saturn Table*, Centaurus 27 (1984), p. 311-317; Id., *Astronomical Papyri*, I, p. 307; Id., *Babylonian Lunar Theory in Egypt: Two New Texts*, in J. M. Steele and A. Imhausen (eds.), *Under One Sky: Astronomy and Mathematics in the Ancient Near East*, Alter Orient und Altes Testament 297, Münster 2002, p. 167-174 ◇ [Pack^{2} 2030; LDAB 4442; *Comunicazioni* 5, p. 69]

Until 1900 it was assumed that Greek knowledge of the motions and phenomena of the moon, as represented by Ptolemy's lunar theory in the *Almagest*, was indebted to the Babylonians chiefly on account of several Babylonian reports of observed lunar eclipses that Hipparchus and Ptolemy used in their theoretical work. Then in his pioneering *Die Babylonische Mondrechnung* Kugler demonstrated that several highly precise lunar periodicities that Ptolemy ascribes to Hipparchus were in fact already in use in Babylonian astronomical tables in Hipparchus' time.[1] This discovery, while obviously important, did not seem to imply that Greek astronomers had direct contact with Babylonian tables; thus Neugebauer could write that "the Babylonian influence did not reach much farther than the communication of some basic concepts and related parameters."[2] His subsequent discovery of a first century Greek papyrus (P. Colker) containing part of an actual table of full moons computed by Babylonian methods indicated the need for a radical reappraisal of the relation between Babylonian and Greek astronomy.[3] The present fragment, which is a description of the columns of a similar table, confirms that a large part at least of the most advanced Babylonian lunar theory was transmitted into Greek and actually in use in Roman Egypt.

The papyrus is of unknown provenance. The text is written along the fibres in a rather calligraphic bookhand that can be dated to the first half of the second century of our era. One column of text is preserved, broken at the top and on both sides but with 4.5 cm lower margin. The continuity of the text with minimal

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[1] F. X. Kugler, *Die Babylonische Mondrechnung*, Freiburg im Breisgau, 1900, 20-40.

[2] O. Neugebauer, *A History of Ancient Mathematical Astronomy*, 3 vols., Berlin 1975, II, p. 604.

[3] O. Neugebauer, "A Babylonian Lunar Ephemeris from Roman Egypt," in E. Leichty, M. deJ. Ellis, and P. Gerardi, eds., *A Scientific Humanist: Studies in Memory of Abraham Sachs*, Occasional Publications of the Samuel Noah Kramer Fund 9, Philadelphia, 1988, 301-304; see also A. Jones, *A Greek Papyrus Containing Babylonian Lunar Theory*, ZPE 119 (1997), p. 167-172 (pl. II).

restorations in many lines shows that the column of text was only slightly wider than the extant fragment. The back is blank.

1492 was listed in Neugebauer 1962 (*supra*), and in Neugebauer 1975 (*supra*). Neugebauer tentatively identified the text as an introduction to planetary tables, a hypothesis that was pursued further in Jones 1984 (*supra*). The interpretation presented here was first proposed in Jones 2002 (*supra*).

Astronomical commentary

The text provides extremely terse column-by-column descriptions of a numerical table that had at least seven columns. The information provided about the various columns is haphazard, and in no instance would a reader unfamiliar with the table be able to generate the contents of a column or even to understand the full meaning of a column merely from the descriptions. Perhaps the text was intended to help an experienced user of such tables to identify the various columns.

From various details, to be discussed below, the table in question can be identified as a variety of lunar table called a "syzygy-table" or "lunar ephemeris," familiar from cuneiform tablets from Babylon and Uruk dating from the third through the first centuries B.C.[4] In a syzygy-table every row of data represents a date of a syzygy, i.e. either a full moon or a new moon, so that the rows in a tablet form a continuous series of dates at intervals of one lunar month covering one or more years. The columns of the table contain various numerical quantities that are involved in the computation of the circumstances of the syzygy. These numbers are generated by arithmetical algorithms, so that each number is usually calculated according to an established rule either from the number in the row above or from the numbers in the columns to the left or from both. In their fullest form, syzygy-tables could have about twenty columns of data leading to the computation of conditions of visibility of the moon on the mornings and evenings closest to the syzygies, but there were also simpler tables (called "auxiliary tables" by Neugebauer) comprising fewer columns and directed to less complex goals such as establishing the date and time of the syzygy itself. Two distinct sets of algorithms for syzygy-tables were employed in Babylonia; these are known as System A and System B. The table described in our papyrus was a System B table of full moons containing columns of data that led to prediction of the date and time of the precise phase and the moon's longitude in the zodiac.

In the Babylonian syzygy-tables, the leftmost column (designated **T** in Neugebauer's nomenclature) normally contained the year and month of the event. Since the Babylonian calendar employed lunar months beginning with the new moon crescent, it was possible to generate this column before calculating the other circu-

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[4] See O. Neugebauer, *Astronomical Cuneiform Texts*, 3 vols., London 1955. The computational principles of the System B tables are described in vol. 1, 69-85. The specific texts that most closely resemble the one described in the papyrus are nos. 170-174, all from Uruk and dating from the late third and early second centuries B.C.

mstances of the syzygies, in particular the precise length of the time interval since the preceding event. In a Greco-Egyptian adaptation of the Babylonian methods one would expect the dates to be expressed in the Egyptian calendar, which was not lunar. Since it is possible for two consecutive full moons or new moons to occur in the same Egyptian month, one cannot forecast the month in which each event falls independently of the day and time of the event. Probably for this reason, the table described in our papyrus does not appear to have had a column **T**; the year and month would instead have been provided in columns described in the lost continuation of the text, to the right of the seventh column.

The leftmost column was therefore the one designated **A**, which contains the number of degrees of longitude that the moon travels between the event of the preceding row and the event of the current row. In System B this quantity is generated by a linear zigzag function, alternately increasing and decreasing between fixed maximum and minimum values by constant steps. The numeral ending in "8" mentioned in line 2 was probably the minimum value of this function (accurately 28;10,39,40°), apparently given as a round number.[5] There does not seem to be space in the gaps of the preserved text for a mention of the maximum value. The διάϲτημα beginning with zero in line 3 was perhaps the line-to-line difference of the function, 0;18°.

The second column is simply characterized as the ἐπιϲυναγομένη or "running total." This is column **B**, the longitude of the syzygy, obtained by adding the number in the same row of column A to the longitude of the row above of column **B**. Longitudes were expressed as zodiacal signs (of 30°) and degrees, with sexagesimal fractions. In Babylonian tables the sign was indicated to the right of the degrees, the reverse of the customary Greek order. Our text reserves the third column for the zodiacal signs, so that in this respect the table was formatted following Babylonian rather than Greek norms.

In the Babylonian tables, a set of columns was dedicated to the calculation of the date of the syzygy. This is found (in a column called **L**) as the running total of the time interval since the preceding syzygy (column **K**), which in turn is 29 days plus the sum of two components **G** and **J**. **G** reflects the moon's varying rate of motion through the zodiac, and is a linear zigzag function. **J** is a correction to take account of the sun's varying rate of motion, and is a nonlinear zigzag function, i.e. the line-to-line differences are variable, constituting in fact a linear zigzag function **H** in their own right. The usual order of columns, from left to right, is **G H J K L**, but in tables that *only* concern the computation of the longitude and date of the syzygies (omitting columns for the lunar latitude and visibility conditions) the normal order is **J G K L** (with **H** omitted). The order prescribed in our text is **H J G**, presumably followed by **K L**. P. Colker similarly appears to have the order **J G**.

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[5] A. Jones, *Studies in the Astronomy of the Roman Period. IV. Planetary Epoch Tables*, Centaurus 40 (1998), p. 1-41.

The fourth column, therefore, is **H**, concerning which we are told four facts: that the "maximum limit" is 21, that this maximum is reached at the longitudes Aries 8° and Libra 8°, that there is no minimum, and that the line-to-line difference (προσθαφαίρεϲιϲ) is a quantity beginning 0;6, with lower-order digits uncertain but apparently ending in "5." The limiting values of **H** in System B are in fact 21 time-degrees (i.e. 360ths of a mean day) for the maximum and 0 time-degrees for the minimum (which is clearly what our text means by saying that there is no minimum), and the difference is 6;47,30 time-degrees. The discrepancy with the attested final "5" in the papyrus is hard to explain, but might indicate that there was a variant version of the rules for computing this column. In Babylonian tables the highest values of **H** do occur in rows where the longitude of the moon, given in column **B**, is near the beginning of Aries or Libra, but it is not strictly true that the maxima coincide with 8° in these signs. These points seem to have been singled out by the author of our text because they are the longitudes of the vernal and autumnal equinoctial points according to System B, though there is in fact no theoretical connection between the equinoctial points and the longitudes where the rate of change in the contribution of variable solar velocity to the time between syzygies is greatest.

The fifth column, **J**, is the running total of **H** although the text fails to state this relation. **J** varies between a minimum 0 time-degrees and a maximum 32;28,6 time-degrees (this last is mentioned in line 13), and because of its relation to **H** the maxima and minima should fall at longitudes approximately midway between the maxima of **H**, in agreement with the text which places these points at Capricorn 8° and Cancer 8°. In a table of full moons column **J** has a positive effect, i.e. it is added to 29 days plus column **G**, in the rows leading up to and following its maximum in Capricorn, whereas in the rows leading up to and following its maximum in Cancer it has a negative effect, i.e. it is subtracted from 29 days plus **G**. This is indicated in the Babylonian texts by signs to the right of the numerals that signify "additive" or "subtractive." Our text reserves the sixth column for this indication, which is only supposed to be written next to the values that are in effect negative. These lines would usually, but not always, be the ones corresponding to longitudes between the end of Virgo and the end of Pisces.

The seventh column, **G**, is characterized as the "course of the moon," which is slightly misleading since "course" (δρόμοϲ) in Greek astronomical texts usually signifies the motion in longitude, whereas **G** is the lunar component of the time between syzygies. The limiting values of the zigzag function for **G** are 172;34,35 time-degrees (written as 1,52;34,35 in the Babylonian sexagesimal notation) and 269;27,5 time-degrees (written as 4,29;27,5). Our text gives the maximum, marred by a scribal error, and is asserting something about the minimum when it breaks off.

ϲ]ε̣λί̣[διν
].[....]ʹηʹ κ[

] δ̣ιάστημα ō ̣[
] δεύτερον cε[λίδιν
5 ἔχει τ]ῆ̣ν ἐπιcυναγομέ[νην.
τρίτον] cελίδιν ζῳ̣δίω[ν.
τέταρτ]ον cελίδιν οὗ ὅροc μ̣[έ-
γιc]τ̣οc μοι(ρῶν) κ̅α̅. τίθεται̣ γ̣[ὰρ
κατὰ τὸν Κρει̣ὸν καὶ τὸ̣ν Ζυ̣[γὸν
10 ἐπ]ὶ μοί(ρᾳ) η̅. ἐλ̣αχίcτην οὐκ ἔ-
χει.] προcθαφαίρεcιc ō ϛʹ μ̣[
]ʹεʹ. πέμπτον cελίδιν ο̣ὗ̣ [ὅ-
ρο]ϲ̣ μέγιcτόc ἐcτιν λʹβʹ [
τίθ]εται γὰρ κατὰ τὴν τοῦ Αἰγ[ό-
15 κερ]ω καὶ Καρκίνου μοί(ραν) η̣̅. [ἕκ-
το]ν cελίδιν ἀπὸ Παρθ[έ-
νου] ἀφαίρεcιc ὡc Ἰχθύων. [ἕβ-
δο]μον cελίδιν δρόμοc cε̣-
λήν]ηc οὗ ὅροc δ̅ κʹεʹ κʹζʹ [
20 τ]ὴν μὲν ἐλαχίcτην η ̣[

8 $\overset{οι}{μ}$ 9 *l.* Κριὸν 10 $\overset{οι}{μ}$ 15 $\overset{οι}{μ}$ 19 κʹεʹ: *l.* κʹθʹ

...column...
...x8...
...interval 0...
The second column
5 has the running total.
The third column consists of the zodiacal signs.
The fourth column, which has a greatest limit
of 21 degrees. For it is placed
at Aries and Libra
10 at 8°. It does not have a least value.
Increment/decrement 0;6,4x,x5.
The fifth column, which has a
greatest limit of 32.
For it is placed at Capricorn
15 and Cancer 8°. The
sixth column, from Virgo
"subtractive" as far as Pisces. The
seventh column, course of the
moon, which has a limit 4;25,27...
20 the least...

2. Since there is a broad space between η′ and κ, the latter is probably not a numeral.

3. Zeros in this line and line 11 are written in the less common form in which the horizontal stroke is *below* the small circle or dot. The only other known papyrus using this form is the astronomical table P.Oxy.Astr. 4174a, which is roughly contemporary with our text; see Jones, *Astronomical Papyri*, I, p. 61-62.

4. There is a broad vacant space at the beginning of this line.

13. There appears to be a broad vacant space at the end of the line.

20. The last letter of the line could be γ, π, or τ.

1492. ASTRONOMICAL TABLE: TEMPLATE FOR SATURN

inv. 2415 Tav. XXX
Oxyrhynchos (cm 11,5 × 30) II^{P}

Bibl.: Neugebauer, *Astronomical Papyri*, pp. 383-391; Neugebauer, II, 790-791; A. Jones, "A Greek Saturn Table," *Centaurus* 27 (1984), pp. 311-317; Id., *Astronomical Papyri*, I, p. 307 ◊ [Pack^{2} 2031; LDAB 4656; *Comunicazioni* 5, p. 69]

Of the present papyrus O. Neugebauer wrote in 1964:

> This fragment is of great historical interest. It is an auxiliary table for the computation of the positions of Saturn between its second stationary point (cτηριγμόc) and its last visibility in the evening (δύcιc). The method followed here is clearly of Babylonian origin, entirely independent of, and very different from, any Greek procedure based on a geometric model with eccentric or epicyclic circular motion. Thus we see that Babylonian procedures which originated in the fourth century B.C. in Mesopotamia were still accessible and freely used in Roman Egypt of the second century A.D. It is now clear that Alexandrian astronomers, even of the time of Ptolemy, had detailed firsthand information about the methods of Babylonian astronomy. This fact is of primary importance for any discussion of the problem of transmission of Babylonian science to the Greeks.[1]

Neugebauer's conclusions have been amply confirmed by more recently published papyri. These include "epoch tables" containing dates and positions of planetary phenomena (e.g. visibilities and stationary points), computed according to attested Babylonian planetary models.[2] Moreover, other tables ("templates") like **1492** have come to light, applying Babylonian-style arithmetical sequences to the description of a planet's day-by-day progress from one phenomenon to the next.[3]

The papyrus derives from Evaristo Breccia's excavations of the kôm Abu-Teir, Oxyrhynchos (1934). The table is written along the fibres in a grid ruled in red except for the triple ruling on the right, which is in faint black ink. The horizontal

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[1] Unpublished typescript.

[2] A. Jones, *Studies in the Astronomy of the Roman Period. IV. Planetary Epoch Tables*, Centaurus 40 (1998), p. 1-41.

[3] For general discussion of these formats of table, see A. Jones, *A Classification of Astronomical Tables on Papyrus*, in N. M. Swerdlow (ed.), *Ancient Astronomy and Celestial Divination*, Cambridge (USA), 1999, p. 299-340, and Jones, *Astronomical Papyri*, I, p. 35-38 and 115-118.

grid lines are two text rows apart, and allow for fifty rows, of which the bottom twelve are vacant. Since the complete table is known to have had 378 rows of numbers, it must have originally had eight sets of three columns like the three in the preserved portion. Margins are preserved at the top (4 cm), bottom (4.5 cm), and right (3.5 cm), although the ruling at the top of the table is prolonged to the right edge. The left edge is broken off. The hand is informal, with some cursive features and ligatures, and can be dated paleographically to the second century A.D. The back is blank.

1492 was described briefly in Neugebauer 1962 (*supra*), and more fully (with a partial translation) in Neugebauer 1975 (*supra*). Neugebauer identified the table as pertaining to Saturn, explained its format and purpose, showed the arithmetical structure of the preserved part of the table, and extrapolated it back as far as the second stationary point. A tentative restoration of the entire table was presented in Jones 1984 (*supra*); this reconstruction is adopted here except for the retrogradation.

Astronomical commentary

The template table of which **1492** is a fragment treated Saturn's synodic cycle as divided into five stages, each starting and ending with one of the planet's synodic phenomena. Column i, tabulated only every five rows as is customary in templates, counts the days elapsed since the epoch (first visibility). Column ii gives the number of degrees of longitude that the planet has travelled since the preceding day, and column iii gives the running total, that is, the longitudinal progress since epoch. The daily progress in each stage was modelled by an arithmetical sequence: of the first order (constant differences from line to line) for the interval from last to first visibility, and of the second order (constant second differences) for the remaining intervals. The longitudes and their differences are expressed as a whole number of degrees followed by three places of sexagesimal fractions.[4] The following reconstruction of the sequences leads exactly to the preserved numbers from the last columns of the table, and is almost certainly correct:

day number	*longitude*	*first difference*	*second difference*
0	0; 0, 0, 0		
First Visibility			
1			
	0; 8,15,18	+0; 8,15,18	
2	0;16,26,22	+0; 8,11, 4	−0; 0, 4,14
3	0;24,33,12	+0; 8, 6,50	−0; 0, 4,14

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[4] As is conventional in modern scholarship, we separate the sexagesimal fractional places from each other by commas, and from the whole number by a semicolon.

...			
116	8; 6,58,28	+0; 0, 8,28	-0; 0, 4,14
117	8 ;7, 2,42	+0; 0, 4,14	-0; 0, 4,14
118	8; 7, 2,42	0	-0; 0, 4,14
First Stationary Point			
119	8; 7, 2,42	0	0
120	8; 6,52,52	-0 ;0, 9,50	-0; 0, 9,50
121	8; 6,33,12	-0; 0,19,40	-0; 0, 9,50
...			
171	4;21,12,22	-0; 8,31,20	-0; 0, 9,50
172	4;12,31,12	-0; 8,41,10	-0; 0, 9,50
173	4; 3,40,12	-0; 8,51, 0	-0; 0, 9,50
Rising at Sunset			
174	3;54,49,12	-0; 8,51, 0	0
175	3;46, 8, 2	-0; 8,41,10	+0; 0, 9,50
176	3;37,36,42	-0; 8,31,20	+0; 0, 9,50
...			
226	0; 0,27,32	-0; 0,19,40	+0; 0, 9,50
227	0; 0,17,42	-0; 0, 9,50	+0; 0, 9,50
228	0; 0,17,42	0	+0; 0, 9,50
Second Stationary Point			
229	0; 0,17,42	0	0
230	0; 0,21,56	+0; 0, 4,14	+0; 0, 4,14
231	0; 0,30,24	+0; 0, 8,18	+0; 0, 4,14
...			
344	7;50,54, 2	+0; 8, 6,50	+0; 0, 4,14
345	7;59, 5, 6	+0; 8,11, 4	+0; 0, 4,14
346	8; 7,20,24	+0; 8,15,18	+0; 0, 4,14
Last Visibility			
347	8;15,35,42	+0; 8,15,18	0
348	8;23,51, 0	+0; 8,15,18	0
349	8;32, 6,18	+0; 8,15,18	0
...			
378	12;31,30, 0	+0; 8,15,18	0

The device of a standard template table to prescribe the daily motion of a planet starting from an arbitrary occurrence of one of its synodic phenomena seems to be a Greek invention – at least, no examples of such tables have turned up on cuneiform tablets – but the representation of the accelerating and decelerating motion by arithmetical sequences is Babylonian.[5] The known Babylonian applications of this approach to planetary motion differ from the templates, firstly in that they are applied to specific dates, and secondly by the presence of sometimes harsh numerical discontinuities between the sequences. The numerical parameters defining the sequences in the Greek template are comparatively few, and most of them again turn out to be Babylonian in origin.

We first consider the choice of 378 days for the duration of Saturn's anomalistic cycle, and the final longitudinal progress, 12;31,30°. Saturn's mean synodic period is approximately 378;6 days, and the corresponding mean progress in longitude is approximately 12;40. Hence 378 days is the closest in whole numbers to the mean period, but the corresponding longitude is slightly low. A figure very close to that in the papyrus can be obtained if one assumes that the (sidereal) year is 365;15,40 days, and that Saturn returns to its initial elongation from the sun after exactly 378 days. Since the sun, according to hypothesis, travels 360° in 365;15,40 days, there remain 378 – 365;15,40 = 12;44,20 days in which the sun travels roughly 0;59° per day, for a total of 12;31,35,40°. If the calculation was along these lines, it owed nothing directly to Babylonian astronomy.

For the subdivision of Saturn's synodic cycle, however, we may compare the template with data in Babylonian procedure texts.[6] These texts express the time interval between the synodic phenomena in units of 1/30 of a lunar month (referred to in modern scholarship as *tithis*). Since two mean lunar months nearly equal 59 days, the approximate equivalents in days are obtained by multiplying by 59/60.

Interval	*Babylonian (tithis)*	*Babylonian (days)*	*Template*
First vis. – First station	120	118	118
First station – Sunset rising	52;30	51;37,30	55
Sunset rising – Second station	60	59	55
(total retrogradation)	(112;30)	(110;37,30)	(110)
Second station – Last vis.	120	118	118
Last vis. – First vis.	undefined		32

There can be no doubt that the time intervals in the template are derived from the Babylonian intervals, the only important difference being that in the template the sunset rising is placed exactly halfway between the two stations, although the

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[5] O. Neugebauer, *A History of Ancient Mathematical Astronomy*, 3 vols., Berlin 1975, I, p. 412-420.

[6] Neugebauer, *History*, I, p. 439-440.

total time of retrogradation is preserved. As an indication that the agreement is not due to chance, it suffices to remark that Saturn's actual retrogradations last always close to 140 days, an entire month longer than is assumed in either the cuneiform texts or the template.

The Babylonian texts also prescribe the number of degrees travelled by Saturn in each stage of the cycle. These numbers are, however, not for the mean synodic cycle, but are associated with the so-called System A model for Saturn according to which the ecliptic is divided into two zones of, respectively, faster and slower motion. Since all the figures are strictly proportional to the overall synodic progress belonging to each zone, it is easy to derive a mean travel for each stage of the cycle from the prescribed travel in (say) the slow zone. The results may again be compared with the template:

Interval	*Babylonian (slow zone)*	*Babylonian (mean)*	*Template*
First vis. – First station	7;30°	8;6°	8;7,2,42
First station – Second station	–6;40°	–7;12°	8;6,45°
Second station – Last vis.	7;33,7,30°	8;9,22,30°	8;7,2,42
Last vis. – First vis.	3;20°	3;36°	4;24,9,36°

Here only the progress in the intervals from first visibility to first station and from second station to last visibility look as if they come from the Babylonian scheme. This is explicable. The person who designed the template evidently intended that the pattern of daily motion should increase by constant steps from zero at the second station to a maximum at last visibility, then keep at precisely that maximum until first visibility, and finally descend by the same constant steps to zero at first station. With the time intervals fixed, such a pattern of daily motion means that one is not free to choose independently the progress in each stage.

Let us suppose that he wanted the progress in the accelerating and decelerating stages to be the average of the two Babylonian figures, i.e. 8;7,41,15°. Since the sum of a sequence of n numbers increasing from zero by constant steps of d is $n(n-1)/2$, and for this stage $n = 118$ days, it follows that $d = 0;0,4,14,20,\ldots$. If we round this to 0;0,4,14 for arithmetical convenience, the total after 118 days is now slightly reduced, 8;7,2,42°, which is of course the number in the template.

The maximum daily motion attained after 118 days is $117d = 0;8,15,18°$. In the 32 days between last and first visibility, this amounts to 4;24,9,36°. The only remaining interval, the retrogradation between the two stationary points, must be equal to the difference between the total progress for the synodic cycle and the sum of twice 8;7,2,42° and 4;24,9,36°. Using the value 12;31,35,40° that we obtained above for the total synodic progress, we find that the retrogradation is –8;6,39,20°. This is supposed to be modelled by two symmetrical 55-day sequences, ascending from zero and descending to zero by constant steps. Using the same formula, therefore, we find $d = 0;0,9,49,53,\ldots$. Again we round this to 0;0,9,50, so that the retrogradation becomes –8;6,45°. This also results in a slight adjustment to the total synodic progress, which now is 12;31,30°. Hence all the numbers in the papyrus follow automatically from the initial choice of the total synodic progress, the time intervals from phenomenon to phenomenon, and the longitudinal progress for just one of these intervals.

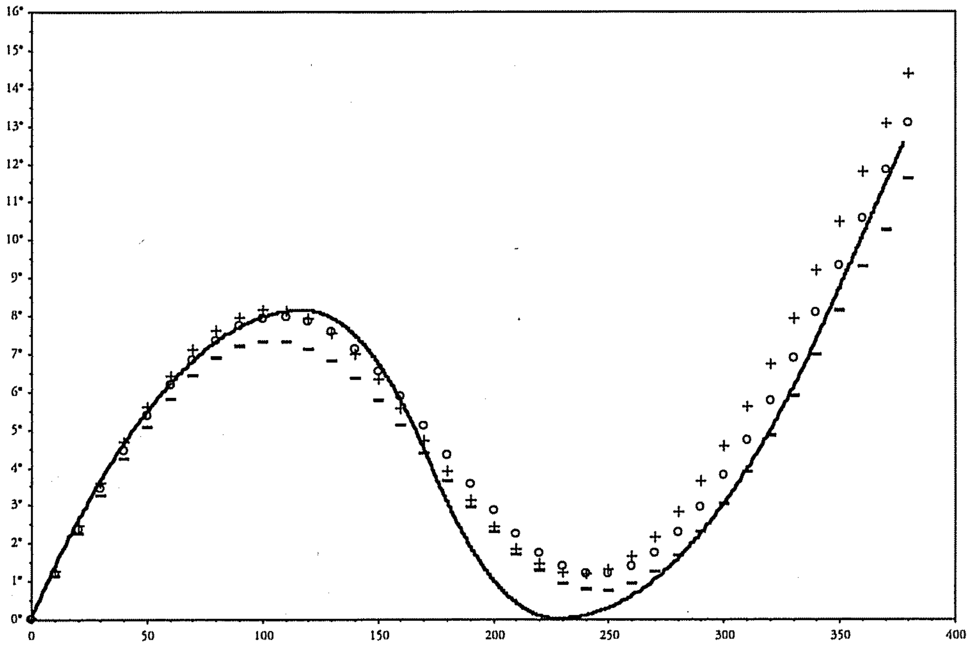

Fig. 1. Longitudinal progress in template compared to Saturn's true progress when near apogee (–), perigee (+), and mean distance (O).

Fig. 1 compares Saturn's longitudinal progress through one synodic cycle according to the template with its actual progress in three situations: near its (geocentric) apogee, near its perigee, and near mean distance. In adopting numerical parameters appropriate for Saturn's mean synodic cycle, the designer of the template appears to have considered that the variations between the planet's actual synodic cycles are small enough to neglect; as the figure shows, this simplification can lead to errors on the order of about 1°, with the largest errors at the end of the cycle. The model itself shows a rather good fit to the mean situation in the intervals of direct motion, whereas errors approaching 2° arise in parts of the retrogradation because the template prescribes too large a retrograde movement in too few days. It is interesting to observe that the rigid numerical structure adopted for the template, which determined the size of the retrogradation, did not lead to larger errors here, and that the maximum daily motion between last and first visibility, which again was purely an arithmetical consequence of the numerical structure, is fairly accurate.

A different approach is taken in the only other template for Saturn so far identified, P. Oxy. Astr. 4166. The latter template, which is also derived from Babylonian parameters, pertains specifically to the slow zone of the System A model, and therefore must have been accompanied by a second template for the fast zone. In this table the progress in the intervals from second station to last visibility (7;30°) and from last to first visibility (3;20°) are taken over independently of each other from the Babylonian scheme, so that the daily progress during the interval of invisibility is much less than the maximum attained just before last visibility. Evidently the planetary templates in use in Roman Egypt did not belong to a single uniform set.

i				ii	iii			
𐆊	η	β	λϛ		ζ	μβ	μζ	ιβ
𐆊	η	ϛ	ν		ζ	ν	νδ	β
𐆊̣	η̣	ια	δ	τμε	ζ̣	νθ	ε	ϛ
𐆊	η	ιε	ιη		η	ζ	κ	κδ
δύϲιϲ								
𐆊	η	ιε	ιη		η	ιε	λε	μβ
𐆊	η	ιε	ιη		η̣	κγ	να	𐆊
[𐆊	η	ι]ε	ιη		η	λβ	ϛ	ιη
[𐆊	η	ι]ε̣	ιη	τν	η	μ	κα	λϛ
[𐆊	η	ι]ε̣	ιη		η	μη	λϛ	νθ
[𐆊	η	ι]ε̣	ιη		η	νϛ	νβ	ιβ
[𐆊	η	ι]ε̣	ιη		θ	ε	ζ	λ
[𐆊	η	ι]ε̣	ιη		θ	ιγ	κβ	μη̣
[𐆊	η	ι]ε̣	ιη	τνε	θ	κα	λη̣	ϛ̣
[𐆊	η	ι]ε̣	ιη		θ	κθ	νγ	κδ̣
[𐆊	η	ι]ε̣	ιη		θ	λη	η	μβ̣
[𐆊	η	ι]ε̣	ιη		θ	μϛ	κδ	𐆊
[𐆊	η	ιε]	ιη		θ	νδ	λθ	ιη
[𐆊	η	ι]ε̣	ιη	τξ	ι	β	νδ	λϛ
[𐆊	η	ιε]	ιη		ι	ια	θ	νδ
[𐆊	η	ι]ε̣	ι̣η		ι	ιθ	κε	ιβ
[𐆊	η	ι]ε̣	ιη		[ι]	κζ	μ	λ
[𐆊	η	ι]ε	ιη		ι̣	λε	[ν]ε̣	μ̣η̣
[𐆊	η	ι]ε	ιη	τξε	ι	μ̣δ	ια	ϛ
[𐆊	η	ι]ε	ιη		ι	ν̣β	κγ	κδ

	[ō	η	ι]ε	ιη		ια	ọ̄	μ̣α̣	μβ
	[ō	η	ι]ε	ιη		ια	η	νζ	ō
	[ō	η	ιε]	ιη		ι̣α	ιζ	ιβ	ιη
	[ō	η	ιε]	ιη	το	ι̣α	κε	κζ	λϛ
30	[ō	η	ιε]	ιη		ια	λγ	μβ	νδ
	[ō	η	ιε]	ιη		ια	μα	νη	ιβ
	[ō	η	ιε]	ιη		ια	ν	ιγ	λ
	[ō	η	ιε]	ιη		ια	νη	κη	μη
	[ō	η	ιε]	ιη	τοε	ιβ	ϛ	μδ	ϛ
35	[ō	η	ιε]	ι̣η̣		ιβ	ιη	νθ	κδ
	[ō	η	ιε	ιη]		ιβ	κγ	ιδ	μβ̣
	[ō	η	ιε	ιη]		ιβ	λα	λ	ō

10 iii νθ: *l.* νδ 25 iii κγ: *l.* κϛ 35 iii ιη: *l.* ιδ

i	ii	iii						
0	8	2	36		7	42	47	12
0	8	6	50		7	50	54	2
0	8	11	4	345	7	59	5	6
0	8	15	18		8	7	20	24
setting								
0	8	15	18		8	15	35	42
0	8	15	18		8	23	51	0
[0	8	1]5	18		8	32	6	18
[0	8	1]5	18	350	8	40	21	36
[0	8	1]5	18		8	48	36	59
[0	8	1]5	18		8	56	52	12
[0	8	1]5	18		9	5	7	30
[0	8	1]5	18		9	13	22	48
[0	8	1]5	18	355	9	21	38	6
[0	8	1]5	18		9	29	53	24
[0	8	1]5	18		9	38	8	42
[0	8	1]5	18		9	46	24	0
[0	8	15]	18		9	54	39	18
[0	8	1]5	18	360	10	2	54	36
[0	8	15]	18		10	11	9	54
[0	8	1]5	18		10	19	25	12
[0	8	1]5	18		[10]	27	40	30
[0	8	1]5	18		10	35	[5]5	48
[0	8	1]5	18	365	10	44	11	6
[0	8	1]5	18		10	52	23	24
[0	8	1]5	18		11	0	41	42
[0	8	1]5	18		11	8	57	0
[0	8	15]	18		11	17	12	18
[0	8	15]	18	370	11	25	27	36
[0	8	15]	18		11	33	42	54
[0	8	15]	18		11	41	58	12
[0	8	15]	18		11	50	13	30
[0	8	15]	18		11	58	28	48
[0	8	15]	18	375	12	6	44	6
[0	8	15]	18		12	18	59	24
[0	8	15	18]		12	23	14	42
[0	8	15	18]		12	31	30	0

1493. ASTRONOMICAL TABLE: TEMPLATE FOR THE MOON

inv. 2416 Tav. XXXI
Oxyrhynchos (cm 7,5 × 16,7) III^{P}

Bibl.: Neugebauer, *Astronomical Papyri*, p. 383–391; Id. *History*, pp. 822-823; A. Jones, *The Development and Transmission of 248-Day Schemes for Lunar Motion in Ancient Astronomy*, Archive for History of Exact Sciences 29 (1983), p. 1-36; Id., *Astronomical Papyri*, I, p. 307 ◇ [Pack^{2} 2032; LDAB 6834; *Comunicazioni* 5, p. 69]

The papyrus, like **1492**, derives from the 1934 excavations at kôm Abu-Teir, Oxyrhynchos. The table is written in a third century cursive hand across the fibres on the back of a fragment from a second or third century document, apparently a transcript of official correspondence (parts of two columns, 23 lines and 25 lines, with upper margin, mentioning ὀξυρυγχείτου (νομοῦ?) in i 17); for this document, see **1490**. Black vertical rulings separate the columns of numerals; the only horizontal ruling is at the bottom of the table.

This papyrus is part of a "template" table setting out the day-by-day progress of the moon in longitude and in argument of latitude. It formed part of a set of lunar tables that saw widespread use from the first to the fourth century A.D. In recent scholarship these tables have been designated the "Standard Lunar Scheme."

Although other Standard Scheme templates have been published to date (P.Oxy. LXI 4150, 4164, 4164a), **1493** was the first to come to light. Neugebauer briefly described it in 1962 (*supra*), and gave a partial translation and commentary in 1975 (*supra*). Neugebauer established the mathematical structure of the text, and identified it as a lunar template. The correct interpretation of columns ii and v as argument of latitude, and a provisional determination of the numerical parameters of the model, were presented in Jones 1983 (*supra*). The exact parameters and the general structure and workings of the Standard Scheme were established in A. Jones *Studies in the Astronomy of the Roman Period. I. The Standard Lunar Scheme*, Centaurus 39 (1997), p. 1-36, and complete reconstructions of the tables appear in Jones 1999 (*supra*), I, 321-342.

Astronomical commentary

The Standard Scheme lunar template is a table listing calculated values for the moon's progress in sidereal longitude (i.e. motion along the ecliptic relative to the stars) and argument of latitude (i.e. motion along the ecliptic relative to the lunar nodes) for either 248 or 303 days starting with an arbitrary epoch date on which the moon is assumed to be at its minimum daily motion. The template was used in conjunction with an "epoch table" listing calculated lunar longitudes and arguments of latitude for a series of epoch dates at 248-day and 303-day intervals; to obtain the longitude and argument of latitude on a given date, one added the values corresponding to the immediately preceding epoch date from the epoch table to the values corresponding to the number of days elapsed since the epoch from the template.

The Standard Scheme, which was invented not later than the first century of our era, assumes that the moon's motion exhibits a single periodic anomaly (variation in rate of progress), reflecting the state of knowledge of the moon's motion before Ptolemy's discovery of the moon's second anomaly ("evection"). The variation in the moon's daily motion, whether reckoned relative to the stars or relative to the nodes, is modelled by arithmetical sequences known as linear zigzag functions, which alternately increase and decrease by constant steps between fixed limiting values. The principle of using linear zigzag functions originated in Babylonian mathematical astronomy of the last three centuries B.C., but the specific numbers that define the Standard Scheme were derived from Greek theoretical research. The progresses in longitude and argument of latitude since epoch tabulated in the template are the running totals of the daily motions.

In the present papyrus the daily motions are not themselves listed, but we have columns containing (from left to right) the number of days since epoch, tabulated only every five lines as is normal for templates, the progress in longitude, and the progress in argument of latitude. Each column had roughly twenty-six lines, so that cols. i and ii of the extant fragment, together with the lost column for the day count which stood to the left of col. i, must be the fourth set of three columns, and cols. iii-v are the fifth set. The complete template, if extending to 248 days, would have required ten sets of columns, or twelve sets if it extended to 303 days.

Longitudes in the Standard Scheme are expressed as usual in degrees and sexagesimal fractions of degrees (minutes, seconds, etc.), but arguments of latitude are expressed in units called "steps" (βαθμοί) such that 1 step is equivalent to 15°. The zigzag functions for the daily motions have the following parameters:[1]

Longitude
minimum $m = 11;42,10,37^\circ$
maximum $M = 14;38,59,7^\circ$
daily change $d = 0;12,50^\circ$

Argument of latitude
minimum $m = 0;47,1,25,45$ steps
maximum $M = 0;58,48,39,45$ steps
daily change $d = 0;0,51,20$ steps

Except for isolated scribal errors, all numbers in the present papyrus agree exactly with the sequence of numbers generated by these parameters, truncated to one fractional place.

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[1] We use the standard notation by which commas separate sexagesimal fractional places and a semicolon separates the integer part from the fractions.

Text

		i		ii	iii		iv		v	vi
	τλς]	ν̣ζ	κβ	μδ	ρ̅ε̅	τζ	μα	κ	νγ	ρ̅[λ̅
	τμθ]	ι̣γ	κγ	αδ		τκ	λα	κα	μδ	
	α	ι]ζ	𐆊	κβ		τλγ	ζ	κβ	λε	
	ιγ]	ζ̣	α	ι		τλε	λ	κγ	κδ	
5	κδ	ν]δ	α	νζ		τνζ	μα	𐆊	ιγ	’
	λς]	ν̣γ	β	με	ρ̅ι̅	θ	λθ	α	α	ρ̣̅[λ̅ε̅
	μθ]	ε̣	γ	λδ		κα	κα	α	μθ	
	ξα]	λ̣	δ	κδ		λγ	ις	β	λς	
	οδ]	η	ε	ιε		με	κα	γ	κε	
10	πς]	ν̣θ	ς	ς		νζ	λθ	δ	ιδ	
	ρ]	β̣	ς	νθ	ρ̅ι̅ε̅	ο	ι	ιε	ε	⸢ρ̅μ̅
	ριγ	ι]θ̣	ζ	νβ		πβ	νγ	ε	νς	
	ρκς	μ]η̣	η	μς		ϙε̣	ν	ς	μη	
	ρμ]	λ̣	θ	μα		ρ[η]	νθ̣	ζ	μ	
15	ρνδ	κ]ε̣	ι	λζ		ρκ̣η̣	κα	η	λδ	
	ρξη	λ]β̣	ια	νδ	ρ̅κ̅	ρ̣λε̣	νς	θ	κθ	⸢ρ̅μ̅ε̅
	ρπβ	ν]γ	ιβ	λα		ρμ̣θ	μ̣γ	ι	κδ	
	ρϙζ	κ]ς̣	ιγ	λ̣		ρξγ	μδ	ια	κ	
	σια	ν]η̣	ιδ	κη̣		ροζ	νζ	ιβ	ιζ	
20	σκς	ι]ζ	ιε	κς		ρϙβ	κ̣γ	ιγ	ιε	
	σμ	κ]γ	ις	κβ	ρ̅κ̅ε̅	⟦ρκε⟧	σζ	β	ιδ ιδ	⸢ρ̅ν̅
	σνδ	ι]ς	ιζ	ιη		θ				
	σξζ]	ν̣ζ	ιη	ιγ		σκα	κ̣η̣	ιε	ιβ	
	σπα	κ]ε	ιθ	ζ		σλε	μβ	ις	θ	
25	σϙδ]	λ̣θ	κ	𐆊		σμθ	μβ	ιζ	ε	
						σξγ	λ	ιη	α̣	

ii 2 αδ: *l.* λδ 16 νδ: *l.* λδ 25 iv 4 τλε: *l.* τμε 7 κα κα: *l.* κα κδ 15 ρκη: *l.* ρκβ 21 ρκε crossed out; the first numeral in col. v belongs with this tabular entry 22 θ: this does not belong to the tabulated series, and its presence here is unexplained v 11 ιε: *l.* ε

i		ii		iii	iv		v		vi
336]	57	22	44	105	307	41	20	53	1[30
349]	13	23	14		320	31	21	44	
1	1]7	0	22		333	7	22	35	
13]	7	1	10		335	30	23	24	
24	5]4	1	57		357	41	0	13	
36]	53	2	45	110	9	39	1	1	1[35
49]	5	3	34		21	21	1	49	
61]	30	4	24		33	16	2	36	
74]	8	5	15		45	21	3	25	
86]	59	6	6		57	39	4	14	
100]	2	6	59	115	70	10	15	5	[140
113	1]9	7	52		82	53	5	56	
126	4]8	8	46		95	50	6	48	
140]	30	9	41		10[8]	59	7	40	
154	2]5	10	37		128	21	8	34	
168	3]2	11	54	120	135	56	9	29	[145
182	5]3	12	31		149	43	10	24	
197	2]6	13	30		163	44	11	20	
211	5]8	14	28		177	57	12	17	
226	1]7	15	26		192	23	13	15	
240	2]3	16	22	125	⟦125⟧	207	2	14 14	[150
254	1]6	17	18		9				
267]	57	18	13		221	28	15	12	
281	2]5	19	7		235	42	16	9	
294]	39	20	0		249	42	17	5	
					263	30	18	1	

1494. ASTROLOGICAL TEXT

inv. 205 Tav. XXXI
Oxyrhynchos (cm 8 × 10) I-II^{P}

Bibl.: Neugebauer-van Hoesen, *Astrological Papyri*, p. 65 (n° 139) ◇ [MP^{3} 2066.3; LDAB 4443; *Comunicazioni* 5, p. 69]

A fragment from a roll, preserving parts of fifteen lines in a hand of documentary character from a single column of text. A small portion of what appears to be a vacant upper margin survives above the latter half of line 1; the column is broken on its remaining sides. The text seems to belong to an astrological treatise, in the present passage setting out principles governing the powers and influences of planets in relation to their positions relative to the sun or moon, among other considerations. The preserved portions of the lines of text may represent only a fraction of the original column width, and in the absence of very close parallels in the astrological literature little can be reconstructed of the precise sense of the passage.

(marg. cm 0,7)
] γενέϲ̣εωϲ̣ παρενϲτα̣[̣ ̣ ̣]ϲ διη̣[
] εὑρίϲκομεν τὰϲ εου[̣]τ̣ων ἀϲτέ[ρων
]ϲ̣ειϲ καὶ ὅτι ˙πᾶϲ ἀϲτὴρ ἀνατολικὸϲ ὑ̣[πάρχων
πρα]κ̣τικοὺϲ τοὺϲ ἐϲομένο̣[υ]ϲ χρόνουϲ ε̣[
ἀνατ]ολικοὺϲ ἀϲτέραϲ ἔχουϲα ἀμφοτεροι̣[
]ο̣υϲι δορυφόρουϲ ὄντεϲ̣ οἰκε⟨ί⟩ωϲ η̣ ̣[
ἐπαν]αφερόμενοι τῇ ϲελήνῃ ἑπομεν[
]π̣οιοῦϲι τῇ τῶν κέντρ[ω]ν̣ μεταϲτ[ροφῇ
] ̣ταϲιν. — ἐπὰν γὰρ ἐν α[
ἐπίκ]εντροι ἤ τε ἀμφότεροι ἢ καὶ ὁπό[τεροϲ
δ]ιαϲτολὰϲ καθ’ ὃ προείπαμεν τ[ρόπον
ἐὰν] δὲ καθ’ ὑπεροχ̣ὴν τῆϲ διαφορ̣[ᾶϲ
] ̣ϲφορούντων ϲωμάτων κα ̣[
ἐ]πὰν γὰρ ἐν ἀρϲενικοῖϲ ζῳ̣δίοιϲ υ[
] ̣[̣] ̣[ ]α̣τ̣η̣[
– – – – –

1. παρενϲτα̣[̣ ̣ ̣]ϲ : no plausible reading can be offered here, or for εου[̣]τ̣ων in line 2.

3. ἀνατολικὸϲ characterizes a planet as being visible at its rising, hence having lower (more westerly) longitude than the sun.

4. πρακτικὸϲ, "productive" or "effective", a characteristic that specific planetary configurations can impart to delimited intervals of an individual's life (χρόνοι); for frequent instances in Vettius Valens and Hephaestio see the indices of Pingree's editions. Line 3 probably preserves part of the conditions leading to the outcome stated in line 4.

6. δορυφόρουϲ, i.e. in the condition of δορυφορία ("spear-bearing"), an astrological relationship determined by the position of a planet relative to the sun or moon. Diverse explanations of δορυφορία are transmitted in the Greek astrological literature; for a comprehensive discussion of the concept see S. Denningmann, *Die astrologische Lehre der Doryphorie. Eine soziomorphe Metapher in der antiken Planetenastrologie* (Beiträge zur Altertumskunde 214), München-Leipzig 2005. The use of the term in lines 6-7 appears to be related to a definition ascribed to the (late Hellenistic?) astrologer Serapio of Alexandria in chapter of an astrological compilation associated with Rhetorius (*CCAG* 8.4, 225-232, esp. 227): δορυφόροι ἀϲτέρεϲ λέγονται ἑῷοι μὲν ⟨οἱ⟩ προαναφερόμενοι ἡλίῳ, ἑϲπέριοι δὲ οἱ προανατέλλοντεϲ μὲν ἡλίῳ, τῇ δὲ ϲελήνῃ ἐπαναφερόμενοι. The conditions for δορυφορία lying behind this apparently corrupted definition are that a planet is a "spear-bearer" to the sun if its longitude is (within a certain conventional number of degrees) less than the sun's, whereas it is a "spear-bearer" of the moon if its longitude is greater than the moon's.

8. τῇ τῶν κέντρων μεταϲτροφῇ, if the restoration is correct, would refer to the shifting zodiacal positions of the κέντροι (the cardinal points where the meridian and horizon intersect the zodiac, i.e. the ascendant, midheaven, setting point, and lower midheaven) resulting from the daily revolution of the heavens.

9. Possible restoration ἐν ἀ[ρϲενικοῖϲ ζῳδίοιϲ, where the "male" signs were by convention the odd-numbered signs counting from Aries; cf. line 14. Probably lines 9-11 belong to a single statement, perhaps referring to the sun and moon or to Venus and Mercury.

13. Perhaps φωϲφορούντων ϲωμάτων, the planets that can appear as morning star, i.e. Venus and Mercury; cf. Paulus Alexandrinus 36.

1495. ASTROLOGICAL TEXT

inv. 151 Tav. XXXII
Oxyrhynchos (cm 7,5 × 13) III^p

Bibl.: Neugebauer-van Hoesen, *Astrological Papyri*, p. 65 (n° 140) ◇ [MP^3 2066.4; LDAB 5235; *Comunicazioni* 5, p. 69]

This fragment of an astrological treatise comes from a discussion of the *dodekatropos*, the division of the zodiac into twelve *topoi* ("houses" in modern astrological terminology) that are determined by the intersections of the ecliptic with the local horizon and meridian planes at any particular time and terrestrial locality. The *topoi* had conventional names, and were numbered in order of successive rising, beginning with the *horoskopos* ("ascendent"), the portion of the ecliptic beginning at its intersection with the eastern horizon and extending one third of the way to its intersection with the part of the meridian below the horizon. The astrological influences associated with the presence of the heavenly bodies in each of the *topoi* constituted one of the conventional topics of general presentations of astrology, for example in Firmicus 3.2-13, Vettius Valens 2.3-14, and Paulus Alexandrinus 24. The present text most closely resembles Valens in the varied and non-systematic character of its material, and there is one close parallel in doctrine between the papyrus and Valens. Influence of Valens on our author is narrowly possible, but a common source tradition appears more likely.

The papyrus is part of a codex page, broken at the top, bottom, and one side but preserving 1 cm margin along the other side on both front (left margin) and back (right). If we are correct in identifying the front (codicological "recto") as the surface inscribed along the fibres, the preserved margin was along the binding. From restorable passages of the text it can be inferred that the breadth of a leaf was at least 10 cm, allowing for lines averaging about 28 letters and 1 cm margin on each side. The hand is a practised "severe" one sloping slightly to the right. Four paragraphi jutting in from the left margin of the front (following lines 3, 8, 9, and 13) indicate sentence or sectional beginnings; none can now be seen on the back, probably because at least 1 cm of text is lost along the left edge. Some sentence breaks are also marked within the text by dicolon (front, lines 3, 8, and 15). Back, line 4 ends with a line-filler, a horizontal stroke serifed on the left.

front (along the fibres)

\- - - - -

τ ̣[
οc διαμετρήcῃ τοῦ οἴκο̣[υ ὁ κύριοc, με-
γάλα ἀγαθὰ δηλοῖ. ἐὰν δὲ [κακοποιὸc

ἐν τῷ ἀγαθῷ δαίμονι οὐκ [ἰϲχύει κα-
κοποιῆϲαι τὴν γένεϲιν ο[
ται τὰ ἀγαθά. ἔτι δὲ ἐὰν τύχ[ῃ ἐν ἰδίοιϲ
προϲώποιϲ, περιποιει .[
τοῦ τόπου· ὁ δὲ ἀγαθοπ[οιὸϲ
ἔϲτιν δὲ ὁ τ̣[όπο]ϲ ι´ μεϲ̣[ουράνημα
τὸ ὕψοϲ τοῦ [...] α̣ὐτη[
χρηματιϲτικὸν τοῦ α[λέ-
γεται διὰ τὸ ὁρίζε̣ι̣[ν .]..[
ϲιν κατὰ μέϲον τὸν κόϲμ̣[ον   ἐ-
φ̣οι ϲύμπα̣[ντ]ε̣ϲ̣ ἀϲτέρεϲ̣ [
ραϲ· ὁ τοῦ Κ̣[ρόνο]υ̣ καὶ ὁ τ̣[οῦ
πλεῖον ὁ το̣[ῦ] Ἄ̣[ρ]εω̣ϲ̣ καὶ ὁ̣ [
δοξα̣[ϲ]τ̣[ι]κο̣[...].περι.[
ηγου̣[   ]πων[
ανδ[κλ]η̣ρώϲη[ται
.]ω̣.[   ].ο̣ντεϲ[
]...[

- - - - -

back (across the fibres)

- - - - -

]α̣[....]..[
ἀγαθῶ]ν πράξεων ἢ κακῶν
] ἕκαϲτοϲ κληρώϲηται
τηλι]κ̣αὐτῷ κατὰ καιρὸν̣ χρό-
νῳ ὅϲον ὁ κλ]ῆ̣ρ̣οϲ ἀπὸ τοῦ ὡροϲκόπου
]..ματοϲ καὶ̣ τ̣ῶν δια-
] ἐ̣πιθεωρούντων ε̣ι
]α̣τυχων. Κρόνοϲ ἐπι-
θεωροῦντοϲ ἐν] τ̣ῷ μεϲουρανήματι Ἡ-
λίου χρηματί]ζει ἔτη λ̅, Ζεὺϲ ἔτη ι̅β̅,
Ἄρηϲ ἔτη ι̅ε̅, Ἀφρο]δ̣ε̣ί̣τη η̅, Ἑρμῆϲ κ̅
ἀ]γαθὰ χ̣ρ̣ονικὰ ϲημαίνου-
ϲιν   ]..αι...ϲ̣υνμ̣ετρία η...
].ροϲ̣[..].[.].[.]τεια κρει-
ἀγαθ]ο̣ποιο[.......]ι̣ϲ εἰϲιν η
]γνωϲη̣[......].[.] χρο-
ἀ]γ̣αθου[   ] μοι-

] ̣ερων[ ]ποι-
]ων π̣λ̣[ ]ε̣ρ̣αϲ
] ̣ ̣[̣] ̣[

– – – – –

front (along the fibres)

– – – – –

[if...]
[the lord] of the sign is diametrically opposite,
it indicates great good things. And if [a malefic is]
in the *Agathos Daimon*, it [lacks the strength] to
do harm to the nativity...
the good things. Moreover if it happens to be [in its own]
decans, it brings about...
of the *topos*; the benefic...
The 10th *topos* is Midheaven,
the height of...
effective in bringing about...
it is so called because it delimits...
at the middle of the cosmos...
all heavenly bodies easterly...
Saturn and...
to a greater degree Mars and...
tending to extol...
...
is allotted...
...
...

– – – – –

back (across the fibres)

– – – – –

...
good or bad actions...
each one is allotted...
to as great a time in due course
[as the] lot [is] from the Ascendant
...
standing in aspect to...
Saturn,
with the sun standing in aspect in the Midheaven,

10 is effective for 30 years, Jupiter for 12 years,
[Mars for 15 years], Venus for 8, Mercury for 20
signify temporally determined good things...
commensurạteness..
...
15 ...
...
...
...
...
20 ...

-----

front

2-3. These lines have a close parallel in Vettius Valens 2.6 (ed. Pingree 61, 13-15): εἰ δὲ καί τιϲ τῶν ἀγαθοποιῶν διάμετροϲ τῷ ἀγαθῷ δαίμονι φανῇ παρόντοϲ τοῦ οἰκοδεϲπότου, μεγάλα καὶ μείζονα ἀγαθὰ καὶ προκοπὰϲ ἀποτελοῦϲιν. This doctrine forms part of Valens' chapter on the eleventh *topos* called *Agathos Daimon*, which must therefore also be the subject of these lines in the papyrus. Probably, as in Valens, the lost preceding text indicated the prosperity resulting from the presence of benefic planets in the eleventh *topos* itself, whereas here the situation involves benefic planets situated in the diametrically opposite *topos* in company with the heavenly body that has lordship over the sign of the eleventh *topos*. It is not clear whether the conditions supposed in these lines of the papyrus are identical to Valens' or just similar. The lost end of line 2 cannot have comprised much more then ten letters, making a restoration along the lines of τοῦ οἰκοδεϲπότου πάροντοϲ impossible.

3-6. Valens continues (ed. Pingree 61, 15-16): εἰ δὲ κακοποιοὶ ϲυμπαρῶϲι τῷ ἀγαθῷ δαίμονι, οὐκ ἰϲχύουϲι κακόν τι δρᾶϲαι, which is very close to the papyrus. 5-6 could be restored, οὐδὲ μειοῦται τὰ ἀγαθά *vel sim.*

6-8. Valens indicates in the opening sentence of his chapter (ed. Pingree 61, 10) that the presence of a benefic planet in a decan (ten-degree zones) that it rules strengthens its enriching influence. Our text may be setting out a more complex statement contrasting the influence of a malefic planet in its own decan (6-8) with that of a benefic in the analogous situation (8).

9. *Mesouranema* is the tenth *topos* counting eastward from the Ascendant; thus our text is running through the *topoi* in reverse order (i.e. beginning with the eastern horizon and running through the *topoi* above the horizon before those that are below). This is the order preferred by Valens (2.5-15). The only other *topos* discussed in the lost text preceding the papyrus' beginning would therefore have been the twelfth.

10. ὕψοϲ seems to be an epithet descriptive of the location of the *Mesouranema* (or, to be more precise, its uppermost endpoint) at the "summit" of the half of the ecliptic that is above the horizon; the expression does not appear to be paralleled in the extant astrological literature.

12-13. The words are suggestive of an explanation of the term ὁρίζων, "horizon", but this is scarcely possible in the context of discussing the *Mesouranema*. Probably some epithet of this *topos* (or μεϲουράνημα itself) is being explained in terms of its function as dividing the eastern and western halves of the sky.

14-21. The paragraphus above line 14 indicates that a new sentence began in the lost end of line 13; the space would allow for ἐὰν ὦcιν, though the continuation of the statement or its general drift are unclear. 15-16 apparently list just four of the planets; there does not seem to be enough space for τῆc 'Αφροδίτηc at the end of either line, so Jupiter and Mercury are likely the missing planets.

17. δοξαcτικὸc is an adjective beloved of astrological authors to characterize influences tending to exalt an individual.

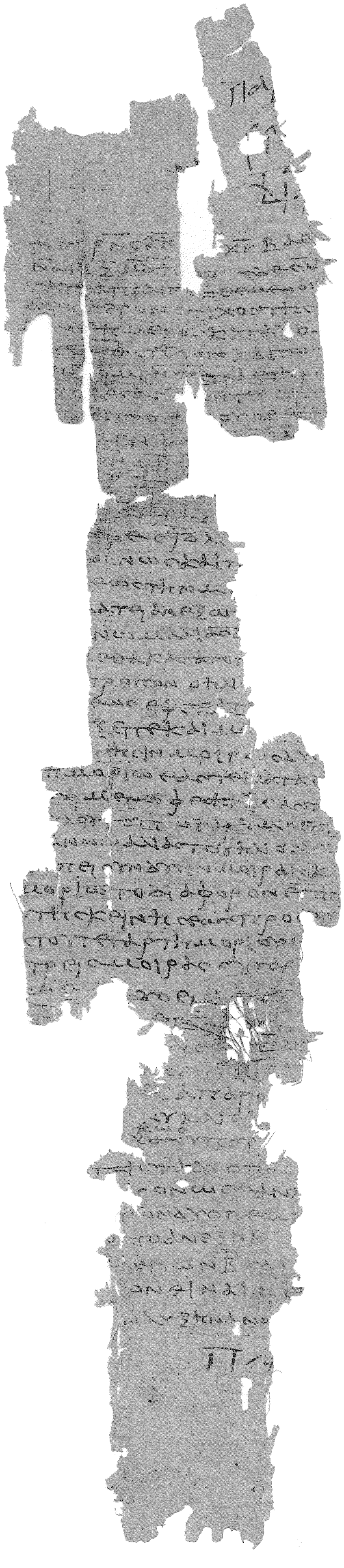
18. The transitive verb κληρῶμαι is again astrological jargon with the sense of "assumes the role or function of".

back

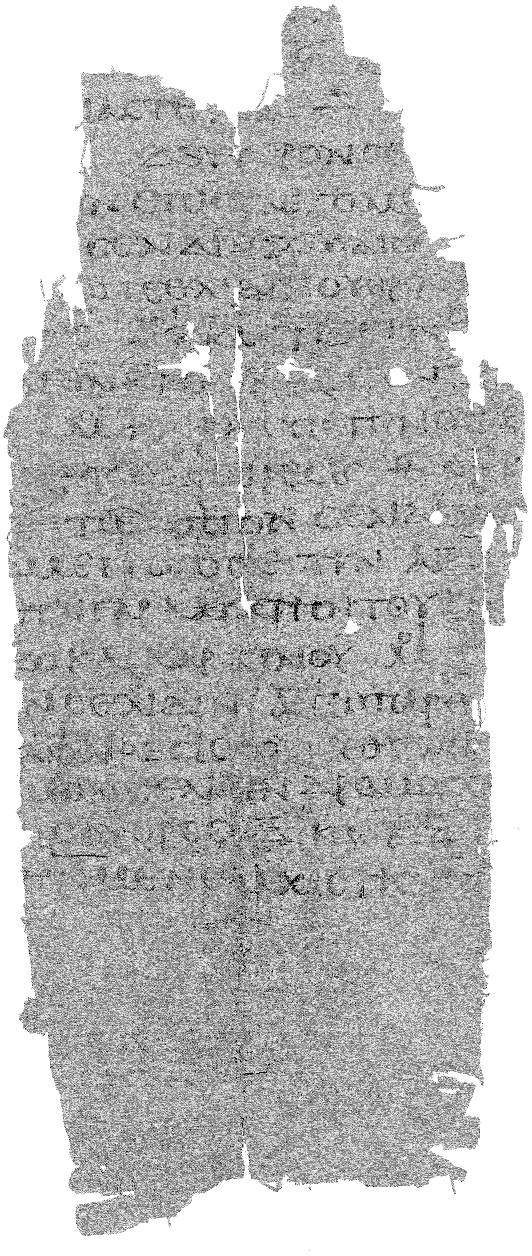
3. Cf. front line 19.

4. Here, if not already in preceding lines, the text takes up the topic of partitioning a person's lifespan into intervals of time according to computations from the positions of the heavenly bodies or astrologically significant points in the zodiac. At least from line 8, the subject is the *chronokratoria*, the assignments of intervals in a person's life to the government of each of the planets in turn. The usual procedure for determining the order in which the planets assume rule (e.g. Firmicus 2.26) was to begin with the sun for diurnal nativities or the moon for nocturnal ones, and to assign subsequent intervals to the planets in the order of their relative eastward elongations from whichever of the luminaries was the "starter" (ἀφέτηc); such an ordering rule does not seem to be explicitly stated in our text. The legible phrases appear to belong to instructions for determining the durations of each planet's governance, for which more than one rule may be involved. In 4-5, time intervals are stated to be dependent on the elongation of a certain "lot" (κλῆροc) from the ascendant point. Usually this would designate one of the several "lots" computed by arithmetical operations upon the longitudes of the ascendant and certain of the heavenly bodies, such as the κλῆροc τύχηc, a point whose elongation from the ascendant is equal to the elongation of the moon from the sun. For the time interval associated with each heavenly body to be determined by the distance of a lot from the ascendant, one would have to have a specific lot for each body, i.e. such a scheme of seven lots as the one set out in Paulus Alexandrinus 23 (περὶ τῶν ἑπτὰ κλήρων τῶν ἐν τῇ Παναρέτῳ). If the elongation in degrees was converted directly into a measure of time, the correspondence would likely have been one month to a degree, which would allow for intervals as great as thirty years.

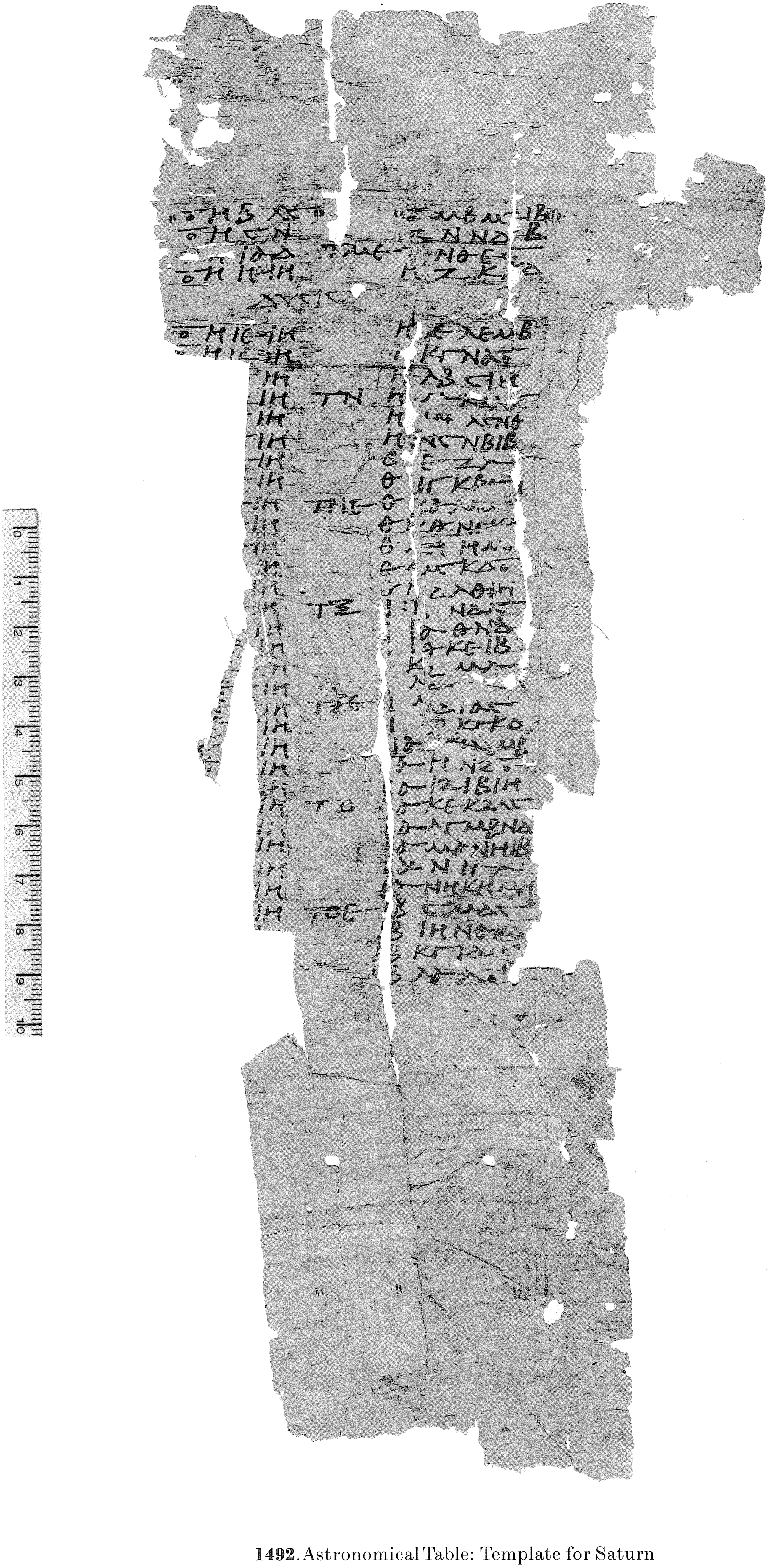
8. The five periods of planetary rule given here appear frequently in astrological texts as part of a scheme that also specified periods of 19 years for the sun and 25 years for the moon; cf. O. Neugebauer and H. B. van Hoesen, *Greek Horoscopes*, Philadelphia 1959, 10. These periods all had originally an astronomical significance. Thus the periods of 30 years for Saturn and 12 years for Jupiter are the approximate lengths of their longitudinal revolutions around the zodiac, while the periods of 15 years for Mars, 8 for Venus, and 20 for Mercury are small whole numbers of years containing close to a whole number of the planet's synodic cycles. In their astrological application in the system of *chronokratoria* they were regarded as maximal values; the usual rule was that a planet governed for its full period if it was located at its exaltation (ὕψωμα) but for only half that period if at its diametrically opposite depression (ταπείνωμα). Here, the criterion for a planet's governing for its full period is that the sun should be in the Midheaven and in aspect (ἐπιθεωρῶν) to the planet, and these conditions also will make the interval prosperous. The continuation may have explained how other situations with respect to the sun affect the duration or quality of the periods, but the text is too broken to make sense of.



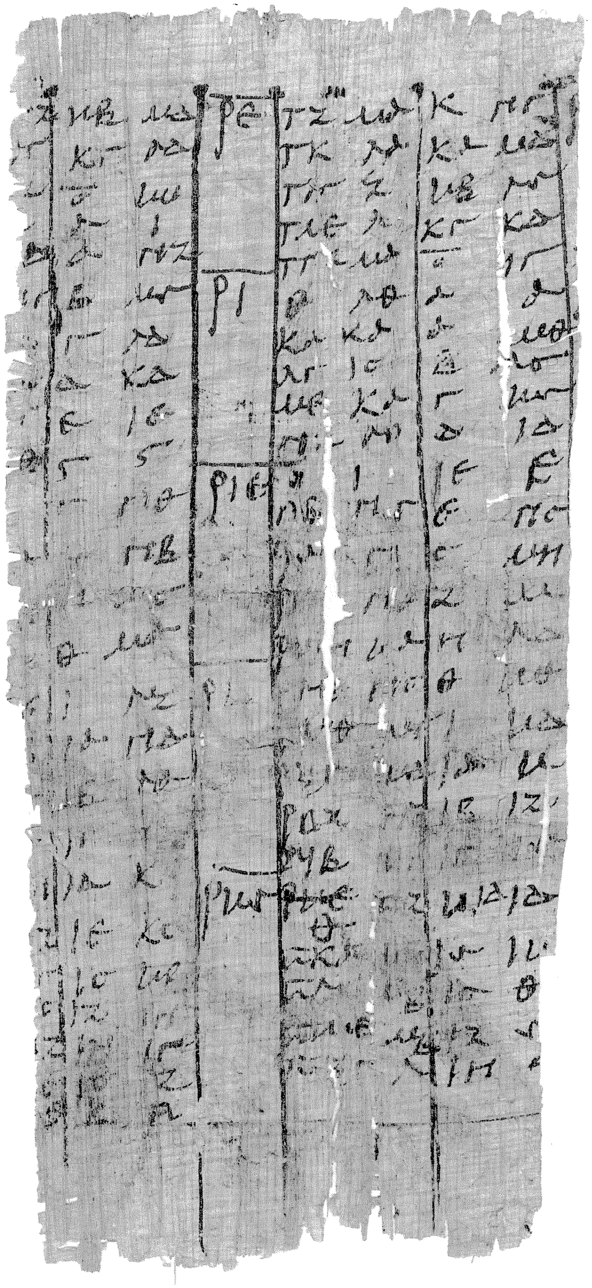
1490. Astronomical Text:
Treatise on Solar Models and Tables



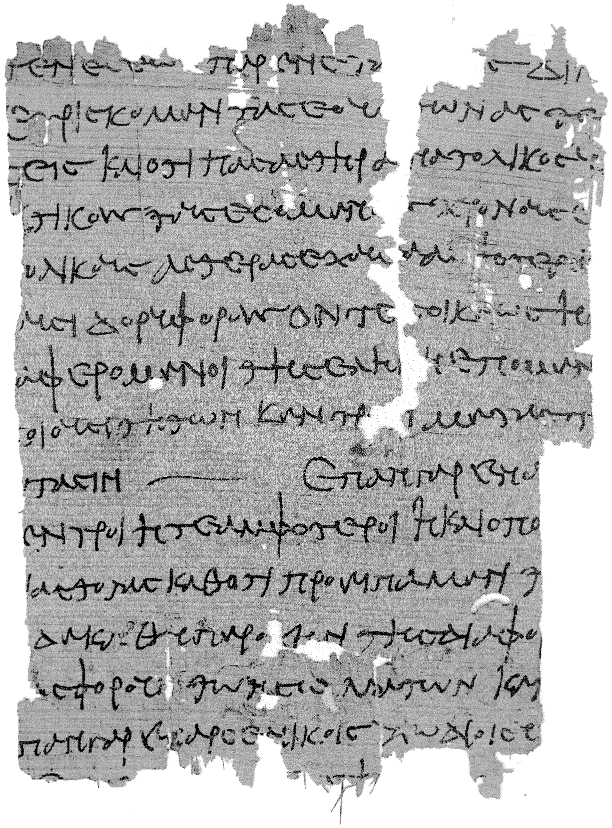
1491. Astronomical Text:
Description of a Lunar Syzygy-Table



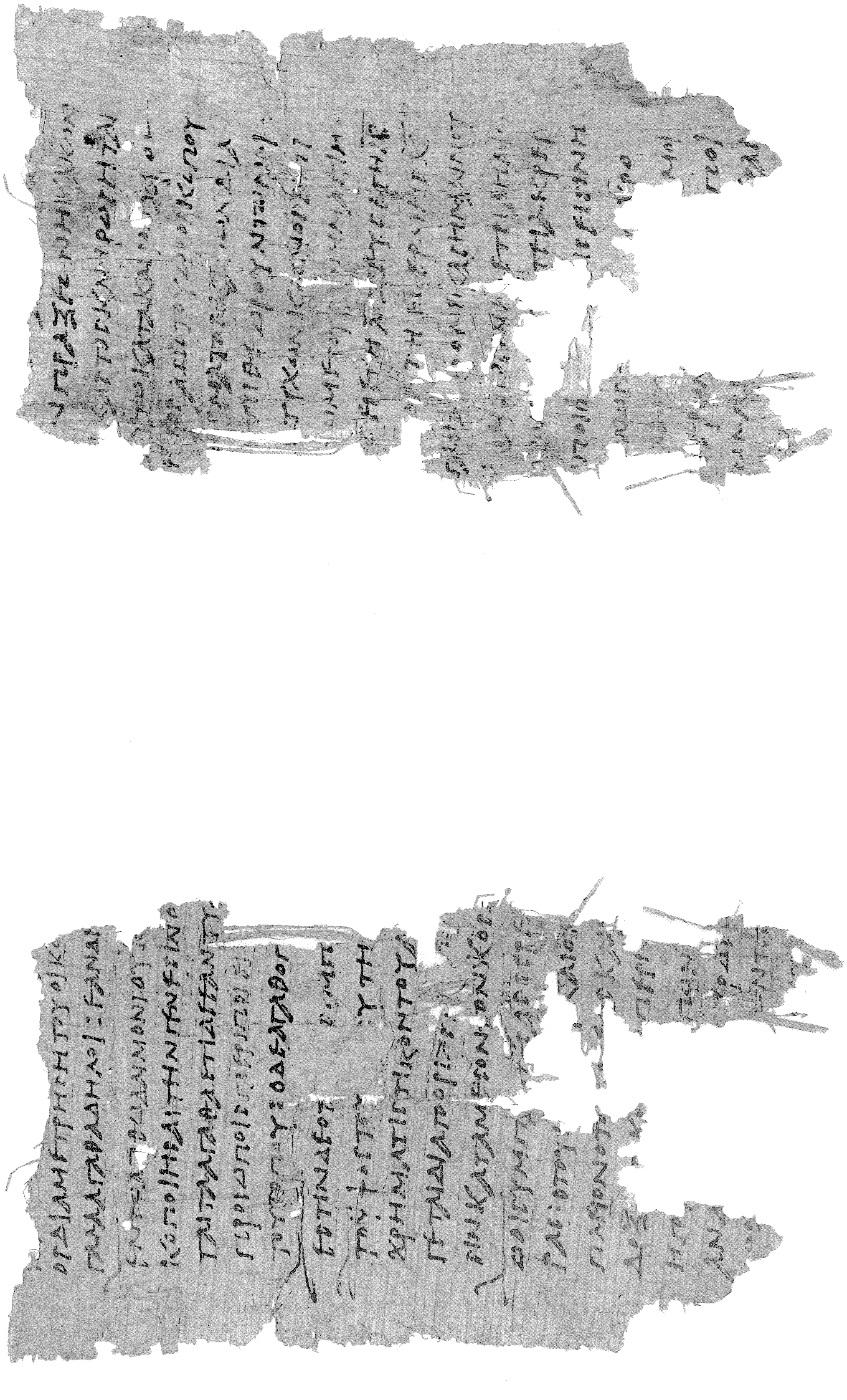
1492. Astronomical Table: Template for Saturn



1493. Astronomical Table: Template for the Moon



1494. Astrological Text



1495. Astrological Text (*recto - verso*)