IG XII,1 913: An Astronomical Inscription from Hellenistic Rhodes

The inscription reedited here, familiar to historians of ancient astronomy by the slightly inaccurate name "Keskinto Inscription", is one of the exceedingly few documents from before the Roman period pertaining to the division of Greek astronomy that used mathematics to describe the motions of the planets. It was discovered in 1893 at a site (in fact a farm estate) called Keskintos (Κέσκιντος) approximately 2.5 km west of Lardos, Rhodes, and the edition by Hiller von Gaertringen in *IG* XII,1 (text 913), made on the basis of a squeeze, has remained the sole authority for the text, although the inscription itself was subsequently brought to Berlin where it now bears the inventory number SK 1472 in the *Antikensammlung*.[1] Paul Tannery, whose study of the inscription at Hiller's instigation resulted in the first and to date the most important insights into the structure and meaning of its contents, pointed out that many of Hiller's readings of the numerals in the inscription require correction, and Hiller adopted some of his suggested revisions in an addendum on p. 207 of *IG* XII,1. Following no less than four papers on the inscription that Tannery produced in 1895 (and one from the previous year by the astronomer Norbert Herz), very little has been written concerning it, most notably a few pages of lucid commentary in Neugebauer's *History of Ancient Mathematical Astronomy*.[2] One suspects that students have been discouraged from revisiting the many unsolved problems relating to the inscription by a sense that too many of the readings are uncertain.

The present edition has been based on my direct inspection of the inscription during August, 2005.[3] Notwithstanding the damaged condition of the stone's surface, many traces of the lettering proved to be visible that presumably could not be seen on Hiller's squeeze (and certainly not in the photograph of the squeeze that Herz published). Further aid in resolving the reading of damaged or missing letters comes from the repetitive pattern of the verbal parts of the top thirteen lines (as Hiller perceived) and from the fact, first recognized by Tannery, that in each of these lines the numeral ending the left half of the line is exactly one tenth the numeral ending the right half. As a result, all the text and numbers in the surviving part of the inscription may now be considered as secure except for the numbers in lines 1 and 4 and, of course, the lost text at the beginnings of lines 14 and 15.

A full study of the astronomical interpretation and historical bearing of the Keskintos Inscription will appear elsewhere.[4] Here, in addition to the description and edition of the text, I will give only a brief commentary with minimal technical discussion.

Description

The stone, of grey marble, has width 77 cm, height 31.5 cm, depth 14 cm. The two sides and the bottom are dressed, but the top face is broken. It can be inferred from the structure of the extant text that at least seven lines have been lost at the beginning, which would mean that the original height of the stone was at

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[1] Tannery consistently gave the name as "Keskinto", and all subsequent scholarship has followed him in this. Hiller, whose Lindian acquaintance Diakos Adelphiu communicated the squeeze to him, used the correct form "Keskintos". On the map of Rhodes in *IG* XII,1 the site is marked about 1.5 km too far to the east; it does not feature on any modern map that I have seen, but is well known in the vicinity of Lardos. Early Christian remains have been found at Keskintos; see *Αρχαιολογικον Δελτιον* 49 (1994) Χρονικα (B2) 811.

[2] The most important of Tannery's papers is L'inscription astronomique de Keskinto, *Revue des Études Grecques* 8 (1895), 49–58. All were reprinted in vol. 2 of his *Mémoires Scientifiques*. See also N. Herz, Über eine unter den Ausgrabungen auf Rhodos gefundene astronomische Inschrift, *Sitzungsberichte der mathematisch-naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften* (Wien) 103 IIa (1894), 1135–1144 and plate, and O. Neugebauer, *A History of Ancient Mathematical Astronomy*, 3 vols., Berlin, 1975, v. 2 pp. 698–705.

[3] I thank Dr. Sylvia Brehme of the Staatliche Museen zu Berlin for facilitating this study and for supplying the excellent photograph reproduced here.

[4] A. Jones, The Keskintos Astronomical Inscription: Text and Interpretation, *SCIAMVS Sources and Commentaries in Exact Sciences* 7 (forthcoming).

The Keskintos Astronomical Inscription (*IG* XII,1 913 = SK 14472)
Staatliche Museen zu Berlin, Preußischer Kulturbesitz, Antikensammlung, Photo Johannes Laurentius

least 44 cm. In addition to general surface damage, the principal other loss of text is from the lower left corner, where a large piece has broken off.

Except for the final dedicatory line, which has letters of approximately 1.4 cm height, the letters are fairly uniformly 0.8 cm in height. Lines 1–13 are laid out as a table in eight columns, with the text or numerals in each column approximately aligned on the left. Hiller estimated the date of writing to be within about half a century either way of 100 B.C.[5] I am not competent to revisit this judgement, which is compatible with the little that we know about the development of Greek astronomy about that time; the author would have been active probably a generation or so after Hipparchus, whose limited contributions to planetary theory are reported by Ptolemy, *Almagest* 9.2.

Unless we include under that heading the conventional notation of placing a small numeral above M for myriads, the only abbreviation in the inscription is M with a small OI above it representing μοῖρα, "degree", in line 14, which I believe is the earliest attested instance of an abbreviation that was to be very common in astronomical papyri of the Roman period. Most of the numbers in the right half of lines 1–13 have what appears to be a simple horizontal stroke following them. I see no such stroke in line 11, where instead there is a second number.[6] Since, as we shall see, this second number certainly represents a fraction, I suspect that the strokes are meant to indicate that a number has no fractional part. In Roman period astronomical papyri this was one of the functions of the "zero" sign, ⊤̄; one wonders if there is some historical connection between the two notations.[7] In the numerals, thousands are indicated by a small raised arc with its concavity pointing right. The numeral form for 6 is ⊏, and that for 900 is Ͳ. There is no clearly legible instance of 90, though I would guess from the visible traces, especially line 9 col. iv, that it took the form ϙ.

Text and translation (pp. 109–110)

In the translation, brackets indicate obliterated text, but no brackets are used in partially legible words. Digits in serious doubt are underlined, and "x" designates digits that are too uncertain even to guess at.

[5] In a letter to Tannery (January 7, 1895), Hiller wrote that the letter forms seemed too „*manieriert*" to be from the early second century, while other considerations such as the presence of iota adscript excluded the second half of the first century; see P. Tannery, *Mémoires scientifiques*, v. 15, Toulouse, 1939, 176–177.

[6] Hiller, however, does report a stroke following the second number, but I suspect he was misled by the squeeze. The strokes are much harder to make out than the letters.

[7] A. Jones, *Astronomical Papyri from Oxyrhynchus*, 2 vols. in 1, Memoirs of the American Philosophical Society 233, 1999, v. 1, 61–62.

Paleographical notes

The following notes are chiefly concerned with the reading of the numerals, since the cyclic structure of the planetary table guarantees all the textual portions.

Line 1. The line runs along the broken upper edge of the stone. In col. iv there appear to be remains of letters, but none can be identified with the slightest confidence. In col. viii it may be presumed that the first sign was a number of myriads, of which only the right bottom serif of the M can be seen, followed by a clear H and parts of two strokes of the next letter: a vertical stroke at the upper left and a vertical stroke at the bottom and a bit further right. According to its astronomical meaning, the expected number in this column would be close to 918500, hence the most likely values for this damaged digit are 4 (Y) or 5 (Φ), of which only Y is consistent with the traces.

2. In col. iv the M is unclear (left half visible only) but certain from context. The traces of the next letter are suggestive of E, while those of the following letters are visible but unidentifiable.

3.The traces of the letter read as T are also compatible with Ͳ (i.e. ϡ).

4. In col. iv a pit has obliterated much of the M. Only upper strokes of the number of myriads, read here as Δ, are visible, and would also be consistent with reading A. The traces of the next letter are strongly suggestive of Ͳ (T is also admissible). Only the bottom of the final digit is visible, and consistent with Δ or E, the counterparts of the two possible readings of the corresponding digit in col. viii. In col. viii the letter following the number of myriads looks like A (alternatively, Δ) in particular one can see a notch that seems to be the vertex of this letter. I am unable to reconcile these traces with the traces of the corresponding digit in col. iv, in which I have slightly more confidence. Traces of what appear to be all four „spokes" of X are visible, though there is sufficient damage to the surface to leave the reading open to doubt. The last letter's right part is missing; what remains is suggestive of N, though M is also possible.

5. The traces of the letters following the initial M are illegible.

6. The traces of the first two letters are suggestive of BY; the remainder is illegible.

7. In col. iv the first letter cannot be read.

9. A pit has obliterated the letters following M in col. viii.

10. Only the vertical stroke of the ϙ in col. iv is visible. In col. viii only the bottom half of K is visible.

11. In col. viii only what appears to be a bit of the loop of ϙ is visible.

12. In col. viii surface damage has rendered unclear the number of myriads.

13. In col. iv only the top right part of B survives. In col. viii the Y is unclear.

14. The numerals in this line were marked as such by horizontal bars over the letters; this bar is visible over TΞ, over the first and third letters of ΘΨK, over the last visible letter of the line, and perhaps over the illegible isolated letter, a trace of which is visible along the broken edge of the stone to the left of the beginning of the legible part of the line. A pit has obliterated the „thousands" stroke preceding ΘΨK. Of the last letter, which was not visible at all to Hiller, besides the stroke marking it as a numeral, there remains a small vertical stroke, apparently a serif, at the upper left, which is compatible with K but not with B (the reading proposed as a restoration by Tannery).

The planetary table

Each half of every line of lines 1–13 has four elements: the name of a planet in the genitive case, a prepositional expression, an adjective or noun in the nominative, and a number. The names of the planets are the descriptive ones well attested in astronomical texts beginning in the third century B.C. rather than the more familiar theophoric expressions "star of Hermes" etc. What we have is the rows of the table pertaining to Mars, Jupiter, and Saturn, preceded by the last of (presumably) four rows pertaining to Mercury. That a set of rows for Venus preceded those for Mercury can be regarded as a practical certainty, but whether there were also rows devoted to the sun and moon is an open question. Tannery recognized that the prepositional phrases are to be taken with the words that follow as specifying a kind of periodic motion associated with the planet. Thus κατὰ μῆκος ζωδιακοὶ are periods of the planet's (generally eastward) revolution around the zodiac, conventionally referred to in modern discussions as "longitudinal" periods; κατὰ πλάτος τροπικοί are periods of the planet's alternating northward and southward motion within the zodiacal belt, referred to as "latitudinal" periods; and κατὰ σχῆμα διέξοδοι are periods of the planet's motion along the zodiac considered relative to the sun, referred to as "synodic" periods. The periods described as κατὰ βάθος περιδρομαί have some relation to a planet's presumed motion towards and away from the earth (which unlike the other motions cannot be directly observed), but their precise meaning constitutes one of the problems of interpretation of the inscription for which I must refer the reader to my more technical study.

Tannery further deduced that the numbers that follow each specification of a kind of period express the number of such periods that are supposed to take place within a very long time interval that is always the same for all numbers in the left half of the table, and again always the same in the right half. The length of these intervals is not explicitly stated in the surviving part of the table, but it can be deduced from the astronomical fact that for any of the so-called superior planets (Mars, Jupiter, and Saturn) the sum of its longitudinal and synodic periods occurring within any interval equals the number of solar years in that interval. Thus we find that the interval for the left side of the table is:

$$15492 + 13648 = 2450 + 26690 = 992 + 28148 = 29140 \text{ solar years}$$

while for the right side the totals are consistently 291400 solar years.

It can be deduced from certain numerical relations among the numbers of periods that the second number 216 following 989 in line 11 col. iv is to be interpreted as a fraction expressed in 360ths of a period, a notation that seems to be uniquely attested in this inscription though it makes sense as an extension to temporal cycles of the division of a circle into 360 degrees (cf. line 14). Thus the number of Saturn's latitudinal periods in 29140 solar years is $989\ {}^{216}/_{360} = 989\ {}^{3}/_{5}$. Except for this specific kind of period for Saturn, and conceivably some of the periods of Mercury and Venus in the lost lines of the table, all the numbers of periods on the left side are whole numbers, while absolutely all the numbers on the right side are whole. Thus we can say that 29140 solar years is an interval within which most of the periodic motions of the planets are supposed to come around to their starting points, while 291400 solar years is an interval within which they all do so; in other words, they are so-called "Great Years" of cosmic recurrence.

This is not the place to review the abundant evidence for doctrines of the Great Year in Greco-Roman philosophy and astrology.[8] The particular Great Years underlying the Keskinto Inscription's numbers are not attested elsewhere. Almost certainly they are to be understood as conversions into solar years (assumed to be exactly $365\ {}^{1}/_{4}$ days) respectively of 29160 and 291600 Egyptian calendar years of 365 days. These numbers in turn were obtained by repeatedly multiplying together the smallest prime factors 2, 3, and 5:

$$2 \times 2 \times 2 \times 3 \times 3 \times 3 \times 3 \times 3 \times 3 \times 5 = 29160$$
$$2 \times 2 \times 2 \times 2 \times 3 \times 3 \times 3 \times 3 \times 3 \times 3 \times 5 \times 5 = 291600$$

Other relations involving small whole numbers are concealed in the numbers of periods belonging to Jupiter and Saturn.

The divisions of the circle

Line 14 comes rather unexpectedly after the planetary table: the table is about time, while this metrological line with which the inscription's astronomy concludes is ostensibly about the measurement of angles or arcs. The connection, hinted at in the expression of a fractional period as 360ths in line 11 col. iv, is probably that the various planetary periods are conceived of as effected by circular revolutions.

[8] An excellent treatment, though not mentioning the Keskintos Inscription, is G. de Callataÿ, *Annus Platonicus: A Study of World Cycles in Greek, Latin and Arabic Sources*, Publications de l'Institut orientaliste de Louvain 47, Louvain-la-Neuve, 1996.

The division of a circle into 360 degrees, a convention of Babylonian origin, is first definitely attested in the work of Hipparchus, thus probably a little before this inscription. This is in fact the only unambiguous trace of Babylonian influence in the inscription's astronomy. A unit of arc called στιγμή is not attested elsewhere. Since line 14, when complete, redundantly stated the relative size of the στιγμή with respect to both the entire circle and the degree, there should have been no room for questioning its definition, were it not that Hiller's squeeze showed no trace of the numeral that stood at the end of the line. Tannery, incredulous at the notion that the circle could be divided into such a peculiar number of units as 9720, rather wilfully insisted that the Θ (which is carved, as elsewhere, as a circle with a central dot) must here be read as an abbreviation for κύκλου, leaving 720 as the number of στιγμαί in a circle and dictating the restoration of B as the lost numeral at the end of the line. Subsequent scholarship has unanimously acquiesced in Tannery's judgement on this point. However, clear traces at the broken edge consistent with K but not with B, along with visible remains of horizontal strokes extending over all the numerals in this line including the Θ prove that 9720 and 27 are the intended numbers. 9720 is exactly one thirtieth of 291600, the duration of the inscription's Great Year in Egyptian years. There may also be a connection with the value Ptolemy adopted (apparently from Hipparchus) for the apparent angular diameter of the sun and moon, which was 1/648 of a circle, i.e. 15 στιγμαί.

The dedication

Line 15 identifies this as a votive inscription. The lost part of the line preceding the first legible letter (this alpha was not seen by Hiller) had room for at most about eighteen letters; the most plausible restoration would thus be θεοῖς πᾶσι καὶ πάσαις or some variant of this formula.

The only known analogue to the Keskintos Inscription as an epigraphical record of numerical details of a planetary system is the so-called Canobic Inscription that Ptolemy erected in A.D. 146/147 at Canopus, of which we have medieval copies of a transcription made in late antiquity.[9] The Canobic Inscription starts off with a dedicatory line, Θεῷ Σωτῆρι Κλαύδιος Πτολεμαῖος ἀρχὰς καὶ ὑποθέσεις μαθημάτων (scil. ἀνέθηκεν), which makes it clear that what is being dedicated is the scientific contents of the inscription itself, not a separate material object. Whether we may infer from the generic similarity of the two texts that the Keskintos Inscription too constituted its own votive offering (an unusual but not unparalleled situation) is not at all clear.[10] Alternatively, the inscription may have accompanied a visual representation of the celestial system, such that the astronomical data recorded in the inscription served as an explanation of or commentary on the display, much as the textual captions accompanying publicly displayed maps did. One can imagine many forms that such a representation might take, including a mobile device (σφαιροποιία).

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[9] A. Jones, Ptolemy's *Canobic Inscription* and Heliodorus' Observation Reports, *SCIAMVS Sources and Commentaries in Exact Sciences* 6 (2005) 53–97.

[10] For inscribed texts as votive offerings see B. H. McLean, *An Introduction to Greek Epigraphy of the Hellenistic and Roman Periods from Alexander the Great down to the Reign of Constantine (323 B.C. – A.D. 337)*, Ann Arbor, 2002, 252.

The Keskintos Astronomical Inscription: Text

i	ii	iii	iv	v	vi	vii	viii
Σ[τίλβοντος]	[κατὰ σχῆμα]	[διέξοδοι]	....	Στίλβ[οντος]	[κατὰ] σχῆμα	διέξοδο[ι]	$\overset{[\mathrm{\varphi A}]}{\mathrm{M}}$ [ʿ]ΗΥ[ ]
Πυ[ρόεντ]ος	κατὰ μῆκ[ο]ς	[ζωι]διακοὶ	$\overset{\mathrm{A}}{\mathrm{M}}$ ʿΕΥϘΒ — .	Πυρόεντος	κατὰ μῆκος	ζωιδια[κοὶ]	$\overset{\mathrm{IE}}{\mathrm{M}}$ ʿΔλΚ
Πυρόεντος	κατὰ πλάτ[ος]	[τρο]πικοὶ	$\overset{\mathrm{A}}{\mathrm{M}}$ ʿΕΥΛϚ [—]	Πυρόεντος	κατὰ πλάτος	τρ[ο]πικοὶ	$\overset{\mathrm{IE}}{\mathrm{M}}$ ʿΔΤΞ
Πυρόεντος	κατὰ βά[θος]	[περι]δρομαὶ	$\overset{\Delta}{\mathrm{M}}$λΞ . —	Πυρόεντος	κατὰ βάθος	περιδρομαὶ	$\overset{\mathrm{M}}{\mathrm{M}}$ ʿΑΧΝ
Πυρόεντος	κατὰ σχ[ῆμα]	[διέ]ξοδοι	$\overset{\mathrm{A}}{\mathrm{M}}$ ʿΓ[ΧΜ]Η — .	Πυρόεντος	κατὰ σχῆμα	διέξοδοι	$\overset{\mathrm{I\Gamma}}{\mathrm{M}}$ ʿϚΥΠ
Φαέθοντος	κατὰ [μῆ]κος	[ζ]ωιδιακοὶ	[ʿ]ΒΥΝ — .	Φαέθοντος	κατὰ μῆκος	ζωιδιακοὶ	$\overset{\mathrm{B}}{\mathrm{M}}$ ʿΔΦ
Φαέθοντος	κατ[ὰ πλ]άτος	τροπικοὶ	ʿΒΥΝϚ —	Φαέθοντος	κατὰ πλάτος	τροπικοὶ	$\overset{\mathrm{B}}{\mathrm{M}}$ ʿΔΦΞ
[Φαέ]θοντος	κατὰ βάθος	περιδρομαὶ	$\overset{\mathrm{B}}{\mathrm{M}}$ ʿΔΣΞ —	Φαέθοντος	κατὰ βάθος	περιδρομαὶ	$\overset{\mathrm{K\Delta}}{\mathrm{M}}$ ʿΒΧ
[Φαέθ]οντος	κατὰ σχῆμα	διέξοδοι	$\overset{\mathrm{B}}{\mathrm{M}}$ ʿϚΧϘ —	Φαέθοντος	κατὰ σχῆμα	διέξοδοι	$\overset{\mathrm{K}\varsigma}{\mathrm{M}}$ [ʿϚλ]
[Φαίνο]ντος	κατὰ μῆκος	ζωιδιακοὶ	λϘΒ —	Φαίνοντος	κατὰ μῆκος	ζωιδιακοὶ	[ʿ]ΘλΚ
[Φαίνοντος]	κατὰ πλάτος	τροπικοὶ	λΑΘ ΣΙϚ	Φαίνοντος	κατὰ πλάτ[ος]	τροπικοὶ	ʿΘΩϘϚ
[Φαίνοντος]	κατὰ βάθος	περιδρομαὶ	$\overset{\mathrm{B}}{\mathrm{M}}$ ʿΖΡΟϚ —	Φα[ίνο]ντος	κα[τ]ὰ βάθος	περιδρομαὶ	$\overset{\mathrm{KZ}}{\mathrm{M}}$ ʿΑΨΞ
[Φαίνοντος]	[κατὰ] σχῆμα	διέξοδοι	$\overset{\mathrm{B}}{\mathrm{M}}$ ʿΗΡΜΗ —	Φαίνοντος	κατὰ σχῆμα	διέξοδοι	$\overset{\mathrm{KH}}{\mathrm{M}}$ ʿΑΥΠ

] . [. . . .] . . . ὁ κύκλος μο(ιρῶν) $\overline{\mathrm{T\Xi}}$, στιγμῶν [ ]$\overline{\Theta\Psi\mathrm{K}}$. ἡ μοῖρα στιγμῶν $\overline{\mathrm{K}}$[Ζ.]

] . . αις χαριστήριον

The Keskintos Astronomical Inscription: Translation

i	ii	iii	iv	v	vi	vii	viii
Mercury	[In relative position]	[passages]	xxxx	Mercury	[In] relative position	passages	[91]84xx
Mars	In longitude	zodiacals	15492	Mars	In longitude	zodiacals	154920
Mars	In latitude	tropicals	15436	Mars	In latitude	tropicals	154360
Mars	In depth	revolutions	4096x	Mars	In depth	revolutions	401650
Mars	In relative position	passages	13648	Mars	In relative position	passages	136480
Jupiter	In longitude	zodiacals	2450	Jupiter	In longitude	zodiacals	24500
Jupiter	In latitude	tropicals	2456	Jupiter	In latitude	tropicals	24560
Jupiter	In depth	revolutions	24260	Jupiter	In depth	revolutions	242600
Jupiter	In relative position	passages	26690	Jupiter	In relative position	passages	266900
Saturn	In longitude	zodiacals	992	Saturn	In longitude	zodiacals	9920
[Saturn]	In latitude	tropicals	989 216	Saturn	In latitude	tropicals	9896
[Saturn]	In depth	revolutions	27176	Saturn	In depth	revolutions	271760
[Saturn]	[In] relative position	passages	28148	Saturn	In relative position	passages	281480

]… A circle comprises 360 degrees or 9720 *stigmai*. A degree comprises 2[7] points.
] to … a thank-offering.

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