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AN ASTRONOMICAL EPHEMERIS FOR A.D. 140: P. HARRIS I.60

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Description: 5.8 x 17.5 cm. The table is written along the fibres in a neat informal hand. Ruling in red, as are the month name and cardinal days of the Roman calendar (represented by slanting type in the transcription). The top margin (1 cm) is preserved. On the back: parts of four lines of cursive.

The astronomical nature of *P. Harris* I.60 was noted by its original editor, J.E. Powell, who also drew attention to its affinity with P. Mich. inv. 1454, a more substantial fragment of an ephemeris, or astronomical calendar, covering part of A.D. 467.[1] Subsequently O. Neugebauer explained the Roman calendar dates in column iv, from which he deduced that the month in question was January, August, or December.[2] He further conjectured (for reasons that are not clear to me) that the month was in fact January, and that column v gave dates in lunar months; but he was unable to make sense of the remainder of the table. In the present article I provide a better transcription of the table, and show how it is possible to establish the structure and purpose of much more of it.

As preserved, the table of *P. Harris* I.60 is divided vertically into four sections: a top margin containing line 1 above a double ruling; five tabular rows separated from each other by single rulings, followed by a double ruling; a single line (7) followed by another double ruling; and the remaining lines 8-32, with single rulings after every second line. This last section is divided into narrower columns by vertical rulings that do not extend above line 8, and originally had 31 lines for the days of the Roman month, which are denoted in column iv. Comparison with P. Mich. inv. 1454 and another ephemeris, P. Vind. G. 29370, suggests that several calendrical columns would have lain to the left of columns containing astronomical data; thus the double ruling to the left of column iv marks the beginning of a set of columns for a month, whereas columns i and ii, delimited to the right by a double ruling, belong to the foregoing month. Neither Powell nor Neugebauer realized that the months in question are actually named in line 1: columns iv and following pertain to August, and the preceding columns to July, which began a few days into the Alexandrian month Epeiph. The intervening column iii is vacant except for a κ every seven days. As Neugebauer remarks, this indicates the passage of weeks, probably in August rather than July. The recurring letter probably signifies Κρόνος, i.e. the day of Saturn in the planetary week. Taking August 7 in line 14 as a Saturday, we find that August 1, which determined the planetary character of the entire month, was Sunday; and indeed the sun is named as the lord of the month in line 7. Column v turns out to give the equivalents of the dates in column iv according to the Alexandrian calendar, in which the twelfth month, Mesore, always begins on July 25.

Continued after the text of the papyrus.

[1] H.D. Curtis and F.E. Robbins, "An Ephemeris of 467 A.D.", *Publications of the Observatory of the University of Michigan* 6.6 (1935).

[2] O. Neugebauer, "Astronomical Papyri and Ostraca: Bibliographical Notes", *Proc. Am. Phil. Soc.* 106 (1962) 383-391, esp. 385.

	i	ii	iii	iv	v
	ʼΕ̅π̣ι̣φ̣ί̣			*Α̅ ὔγου̣[ϲτοϲ*	
	α] ἰ̣χ̣θ̣(ύϲι) γ κ̣γ̣´			ᾱ ἰχ̣θ[ύϲι	
	] ι̅ζ̅ ´ ̣ ̣ἐ̣ῷ̣(οϲ)			ᾱ κα[ρκίνῳ	
4	] λ̣έ̣(οντι) ᾱ			ᾱ λέο̣[ντι	
	] κ̣θ			ι̅β̅ καρ̣[κίνῳ	
	ι]β̣ [κα(ρκίνῳ)] ◦̅ λ̅ λέο(ντι) ◦̣̅			ιζ ἑ̣[ϲπέριοϲ	
	┌───── ̣ ̣ ̣			*ἥλιοϲ*	
8	] ιη	δ ̣ -		*κ̣αλ*	η
	] β̣	[ ]		δ	[θ
	]	ι̣ζ̣ η-		γ	[ι
	]			α	[ια
12		]		[*νων*]	[ιβ
		]		[η]	ιγ
		]	κ	ζ	ιδ
		]-		ς̣	ιε
16		]		ε̣	ις
		]		δ	ιζ
		]		γ	ιη
		]		α	ιθ
20		]-		*ε̣ἰ̣ δοί̣*	[κ
		]	κ	ι̣θ̣	[κα
		]		ι̣η	[κβ
		]		ιζ	κ[γ
24		]		ις	[κδ
		]		ιε	[κε
		]		ιδ	κ̣[ς
		]		ι̣γ̣	[κζ
28		]	κ	ιβ	κ[η
		]		ια	κ[θ
		]		ι	[λ
		]		θ	[α
32			]	η̣	[β

2 γ̣, possibly ς̣ 7 traces of letters (̣μ̣ ̣ ?) below a long horizontal stroke 8 perhaps δ γ̣ ?

	i	ii	iii	iv	v
	Epeiph			*August*	
	1] Pisces 3°?23'?			1 Pisces [	
	] 17… morning visibility			1 Cancer [	
4	] Leo 1°			1 Leo [	
	] 29			12 Cancer [	
	1]2 [Cancer] 0° 30 Leo 0°			17 evening visibility? [	
	] . . .			*Sun*	
8	] 18	…		*kalends*	8
	] 2	[ ]		4	[9
	]	…		3	[10
	]			1	[11
12		]		[*nones*]	[12
		]		[8]	13
		]	k	7	14
		]-		6	15
16		]		5	16
		]		4	17
		]		3	18
		]		1	19
20		]-		*ides*	[20
		]	k	19	[21
		]		18	[22
		]		17	2[3
24		]		16	[24
		]		15	[25
		]		14	2[6
		]		13	[27
28		]	k	12	2[8
		]		11	2[9
		]		10	[30
		]		9	[1
32			]	8	[2

Still unaccounted for are the five rows 2-6. The number, together with the clear indications of zodiacal signs in col. iv, lines 2-5, suggests that these rows recorded positions of the five planets during the month. We know from other Greco-Egyptian almanacs that particular importance adhered to the dates on which a planet crossed from one zodiacal sign to another, and those on which its first and last visibilities and stationary points occurred.[3] If lines 2-6 contained the dates and positions of such planetary events, then we would expect the rows to have followed the standard planetary sequence Saturn, Jupiter, Mars, Venus, Mercury, which is prevalent in papyrus horoscopes and almanacs. On this hypothesis it should be possible to establish the date on which the planets had approximately the positions recorded; and conversely, if such a date can be found that also matches the other information on the papyrus, our explanation of the nature of these rows will be confirmed.

As usual when dating a document from planetary positions, it is easiest to begin by using the slowest bodies, Saturn and Jupiter, to find a range of possible rough dates, which are then narrowed down by means of other planets. From col. iv, lines 2-3, we have Saturn in Pisces and Jupiter in Cancer on August 1. Tuckerman's tables[4] show that this configuration occurred in A.D. 21-22, and thereafter at intervals of roughly 59 years. Adding the requirement that Mars be in Leo on August 1 eliminates all years before 500 except 140, 317, and 377. Requiring Venus to be in Cancer on August 12 leaves only 140 as a possible date. That this is the correct date for the papyrus is confirmed, firstly by Mercury's presence in Leo in July of 140 (cf. col. i, line 6), and secondly by the fact that August 1, 140, was a Sunday. It is practically certain from the nature of the table that it was computed very close to the year to which it refers; Powell's dating to the third century merely confirms that palaeographical dating is not reliable for numerical tables.

We may compare in greater detail the actual movements of the planets during July and August of 140 with the entries in the papyrus. Saturn was in Pisces throughout the interval, travelling retrograde since its station about June 20. Since no sign entries or phases took place during July or August, the entries give the longitude (degrees and minutes?) on the first of the month. Jupiter was invisible in Cancer towards the beginning of July, conjunction occurring about July 5, and first visibility in the morning about two weeks later. This event is recorded for July 17 (apparently without longitude); and the position on August 1 fills the space for this otherwise eventless month. For Mars, the sign entry into Leo in late July, and its position on August 1 are recorded; the planet was invisible until late August or early September. Venus's entry into Cancer is reported for August 12, about a week later than one finds by modern computation; hence the longitudes of Venus in the papyrus were several degrees too low. Entry into Gemini should have been predicted for about July 15; the extant traces may belong to the minutes of longitude. Lastly, Mercury ceased to be visible as morning star in late June, and crossed into Cancer in early July; while still invisible, it entered Leo about August 5, and reappeared as evening star not long after. In the papyrus, the crossing

[3] For a list and description of such almanacs, see O. Neugebauer, *A History of Ancient Mathematical Astronomy*, Berlin 1975, 785-789, to which list may be added *P. Laur.* III/423 (*ZPE* 30 [1978] 211-218), *P. Vindob. G.* 36041 (*ZPE* 37 [1980] 285-293), *Tab. Amst. inv.* 1 (*CE* 52 [1977] 301-310), and *P. Oxy.* XLVI.3299.

[4] B. Tuckerman, *Planetary, Lunar, and Solar Positions*, A.D. 2 to A.D. 1649 (Mem. Am. Phil. Soc. 59), Philadelphia 1964.

into Leo is reported for July 30, crowded into the space left by the sign entry into Cancer, while the preserved entry for August 17 must refer to the appearance as morning star.

The space needed for a month's planetary entries does not seem to have exceeded 7 cm, which would allow for six or seven narrow columns in the lower part of the ephemeris. The first two columns are known to contain Roman and Alexandrian dates. Others may have given equivalents in other calendars, e.g. the old Egyptian calendar or dates in lunar months. A column for solar longitudes may also have been present. The second last column, partially preserved for July (col. i), evidently was for the degrees and minutes of lunar longitude, and would have been preceded by one giving the zodiacal sign. I do not know the purpose of the last column (ii), nor can I read what is written in the heading space (line 7) above it.

P. Harris I.60 represents a new type of astronomical table. We have many examples of almanacs that list dates (either Alexanrian or old Egyptian) of planetary sign entries and phases (see note 3). The ephemeris from 467, *P. Mich. inv.* 1454, gives day-by-day positions of all seven heavenly bodies in parallel columns according to the Roman calendar, with columns for the Alexandrian calendar and days of the lunar month. Another late ephemeris (*P. Vindob. G.* 29370) has a similar format, but tabulates positions only of the moon and its ascending node.[5] The present papyrus combines elements of almanac and ephemeris, giving day-by-day lunar positions and calendrical concordances, but only highlights of the planets' progress. I think this reflects a change in methods of astronomical computation after the second century. Earlier procedures for predicting planetary motion, derived ultimately from Babylonian astronomy, began by establishing the dates and positions of the successive planetary phases, and obtained intermediate longitudes by interpolation. Finding dates of sign entry and longitudes on the first day of the month by these methods was fairly easy, and this information was precise enough for most astrological applications. Ptolemy's tables, which came into use during the late second century, made it possible to compute planetary positions on any day or succession of days directly, but made the determination of sign entries and phases much more laborious and awkward. The format of the astronomical ephemeris evolved to accommodate the kind of information that the new tables could best provide.

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[5] H. Gerstinger and O. Neugebauer, "Astronomische Papyri aus Wiener Sammlungen", *Sb. Österr. Akad. d. Wissenschaften*, philos.-hist. Kl. 240.2 (1962), 1-25. For the date, see Neugebauer, *Hist. Anc. Math. Astron.* 1057-1058.