FRAGMENT OF A GREEK PLANETARY TABLE

The papyrus which is published here belongs to the collection of the Library of Trinity College, Dublin, and has the inventory number TCD Pap. F. 7.[1] It measures 8 x 8 cm. The complete papyrus would have had a height of 38 cm. and a width of at least 130 cm., see below.

The fragment is irregularly broken off on all sides, except for the bottom, where there is a margin of 2,7 cm.

By means of red double vertical lines and single horizontal lines (except for the bottom double line) the papyrus is divided into four columns which I shall call A, B, C and D respectively.

The papyrus is mounted on cardboard, so the back is supposed to be blank. Its provenance is unknown; it was probably bought by Prof. J.G.Smyly before 1940.

The tables are carefully written along the fibres in a clear, upright, literary hand, and can be compared to W.Schubart, Papyri Graecae Berolinenses, plate 31 (2nd century A.D.) and R.Seider, Paläographie der griechischen Papyri II, plate 28 (mid 2nd century A.D.), but we should keep in mind the warning of Prof. Neugebauer against "applying criteria which were gathered from totally different types of manuscripts to texts which contain, for the most part, tabular matter".[2] The handwriting also resembles P.Heid. inv.4144 + P.Mich. 3. 151,[3] dated by the first editors of P.Mich. (on palaeographical grounds) to the third century A.D.

Transcription

P.Dublin inv. TCD Pap. F.7 Plate VI

	A	B	C	D
1	ↄͨ͞c	α̣ [ ]		
1a	ἰχθύ(ων)			
2	]. ϑ	α̣ [ ]		
3	]. ιη	β [ ]		
4	]· κϛ	γ̣ κ̣ζ	ι̣η μ̣[ ]	
5	] λε	δ ια	ιη κ	
6	] μγ	δ νε	ιζ νϛ	κ̣γ [ ]
7	] να	ε λϑ	ιζ λγ	κε .[ ]
8	]· νϑ	ϛ κδ	ιζ ϑ	κϛ μ[ ]
9	] ζ	ζ η	ιϛ μϛ	κη ιβ

1) I am very grateful to the Board of Trinity College in Dublin for permission to publish this papyrus and for the photograph. I also wish to thank

Translation

	A	B		C		D	
		[Taurus]					
		[0°	31′]				
1	0′	1°	[15′]				
1a	Pisces						
2	9′	1°	[59′]				
3	18′	2°	[43′]				
4	26′	3°	27′	18°	4[3′]		
5	35′	4°	11′	18°	20′		
6	43′	4°	55′	17°	56′	23°	[42′]
7	51′	5°	39′	17°	33′	25°	[12′]
8	59′	6°	24′	17°	9′	26°	4[2′]
9	7′	7°	8′	16°	46′	28°	12′

(The restorations for the minutes in col. B, C and esp. D may be slightly off.)

Remarks

line 1. ↄ͞ο͞c : symbol for zero, also to be found in other astronomical tables, e.g. P.Ryl. 3. 523 and P.Nelson (BASP 7, p.35-38 and plate, cf. P.37 n.2-4). The symbol is not only used in the degree positions, as was stated there; here and in P.Ryl. 523 it has the position for the minutes.

Other forms of this symbol are ο͞ο͞ο (e.g. P.Lund. inv. 35a),[4] ⌈ο⌉ (e.g. P.Aberd. 128 descr.), ⸗ (e.g. P.Mich. 3. 150 and 151) and ⸌ (e.g. P. Berol.inv.21236, ZPE 20,p.117-8). It is not derived from οὐ(δέν).[5]

line 2. Beginning: probably a (less carefully written) symbol for zero. On the papyrus the little downward stroke is visible.

lines 4,6,8,9. Two ways of writing the stigma, ϛ and c, are used side by side, seemingly without any differentiation.

line 9. The lower traces at the edge of this line, which are still visible on the photograph, did not belong to the papyrus and were removed.

Commentary

The arrangement of the columns with sexagesimal numbers between the red

Dr. W.Clarysse for drawing my attention to this papyrus and for checking my readings on the original during his summer holidays in Ireland; Prof. O. Neugebauer who read a first draft of this article, for the remarks which he sent me by his letter of July 8, 1981; my brother C.J.Hoogendijk, a mathematical student, for his help on astronomical matter; and J.H.Enterman for helping me with my English.

2) O.Neugebauer, An Astronomical Almanac for the Year 348/9 (P.Heid.Inv. No.34), Hist.Filol.Medd.Dan.Vid.Selsk. 36, 4 (1956), p.5.

3) O.Neugebauer, A New Greek Astronomical Table (P.Heid.Inv. 4144 + P. Mich. 151), Hist.Filos.Medd.Dan.Vid.Selsk. 39, 1 (1960), p.3-8 and plate.

4) Plate: O.Neugebauer, Exact Sciences in Antiquity (1952), plate II; for the symbol zero cf. p.13-14.

5) O.Neugebauer concludes this e.g. in o.c. (note 3), p.1, note 1.

lines, and the word ἰχθύ(ων) (denoting the zodiacal sign Pisces) show that we are dealing here with an astronomical table. From the decreasing numbers in col. C we may infer that this is a planetary table, stating the longitudes of certain planets in degrees and minutes in a zodiacal sign (the figures never surpass 30 because each zodiacal sign consists of 30 degrees), with col. C expressing the backward motion, or retrogradation, of a planet.

About 40 Greek (and Demotic) planetary tables survived on papyrus,[6] but none of them are completely similar to ours.

There are two types of arrangement of these tables:[7]

1) Certain events in planetary motion are registered together with the date (month and day, written in numbers) of entry in a new zodiacal sign (also in numbers) of a certain planet (when the different planets are mentioned, they too are numbered).[8] This is the normal Greek/Egyptian way of tabulating.

2) The positions of the planets are registered with equal intervals of time (e.g. day-by-day-tables, ephemerides, but intervals of 2, 3, 5 and 10 days are also possible). This is the old Babylonian structure, revived from the second century onwards in Egypt, as can be seen from the astronomical papyri.[9] In these tables the dates are mentioned together with each planetary position (note 9 papyri nrs. 1-3), or else given in the first column(s) of the table, so that each date concerns the positions in all the corresponding lines of the following columns (note 9 nrs. 4 and 5). The planetary tables were meant for use in astrology. They were necessary to calculate the position of the planets for any given time, in order to cast horoscopes.[10]

Let us now return to our table: we see degrees and minutes, probably denoting the position of a planet (maybe, but not necessarily, mentioned on top of a column). In col. A we have positions within Pisces (i.e. 330°-360°). No dates are mentioned, so we must be dealing with a table of the second type, which does not give a special date for each item. It is possible that the dates are tabulated in a preceding column; in that case we expect that the positions of different planets are stated in each column. There are, however, reasons to think that the date was so evident (e.g. in the case of day-by-

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6) For a complete survey of planetary tables see O.Neugebauer, A History of Ancient Mathematical Astronomy (1975), Part Two, p.787-8, 945-8 and 1055-8; to which must now be added: O.Neugebauer-W.Brashear, An Ephemeris for Mars, ZPE 20 (1976), p.117-8; O.Neugebauer-P.J.Sijpesteijn-K.A.Worp, A Greek Planetary Table, Chron. d'Eg. 52 (1977), p.301-310; O.Neugebauer-R.Pintaudi, Pap.Laurentiana III/423: A Planetary Table, ZPE 30 (1978), p.211-218; P.Oxy. 46. 3299; O.Neugebauer-P.J.Sijpesteijn, A New Version of Greek Planetary Tables, ZPE 37 (1980), p.285-293.

7) Cf. O.Neugebauer, o.c. (note 6), p.785.

8) E.g. the four most recently published tables added in note 6.

9) Cf. O.Neugebauer, o.c. (note 6), p.1055-1058, papyri nrs. 1-5. These ephemerides are mostly written on codices (p.1056 + n.6), but this is not probable for our papyrus, since the back is blank.

10) Many horoscopes on papyrus survived, see O.Neugebauer-H.B. van Hoesen, Greek Horoscopes (1959).

day positions), that it was not mentioned in a preceding column:

- the double red vertical lines and empty spaces make such a clear separation between the columns, that one is inclined to think that they can only be read vertically and have no connections horizontally (as in P.Heid. inv. 4144 + P.Mich. 151, a table of synodic arcs for Mars[11] for which unfortunately no further explanation has been found as yet, and P.Berol. inv. 21236, ZPE 20 p.117-8, an ephemeris for Mars)

- the numbers of the four columns, esp. of B,C and D, seem to be part of the same progression of numbers (the loss at the top of the papyrus is enough to let the numbers follow up), so all the columns would concern one and the same planet; in fact, the difference between the numerical progressions of each column seems too small to account for different planets, see table:

Table of differences with respect to the preceding numbers

	A	B	C	D
2	?° 9′			
3	?° 9′			
4	?° 8′			
5	?° 9′	0° 44′		
6	?° 8′	0° 44′	- 0° 24′	
7	?° 8′	0° 44′	- 0° 23′	
8	?° 8′	0° 45′	- 0° 24′	
9	?° 8′	0° 44′	- 0° 23′	1° (23-32)′

Looking at columns B, C and D it may be possible that they represent (in longitudinal degrees with equal time intervals, for which we shall choose one day at a time, because of the small increase) the motion of a certain planet, moving with different velocity in the different phases of its orbit. The planet would pass through almost one whole zodiacal sign (from 1° in col. B to 28° in col. D) in two columns and about eleven lines, with retrogradation in between.

The planet in question may be Venus. Its mean daily motion amounts to 1,6022°[12] ≈ 1°36′, its mean motion during the retrogradation to 0°21′ and the mean duration of the retrogradation to 41 2/3 day,[13] which would all fit the papyrus very well.

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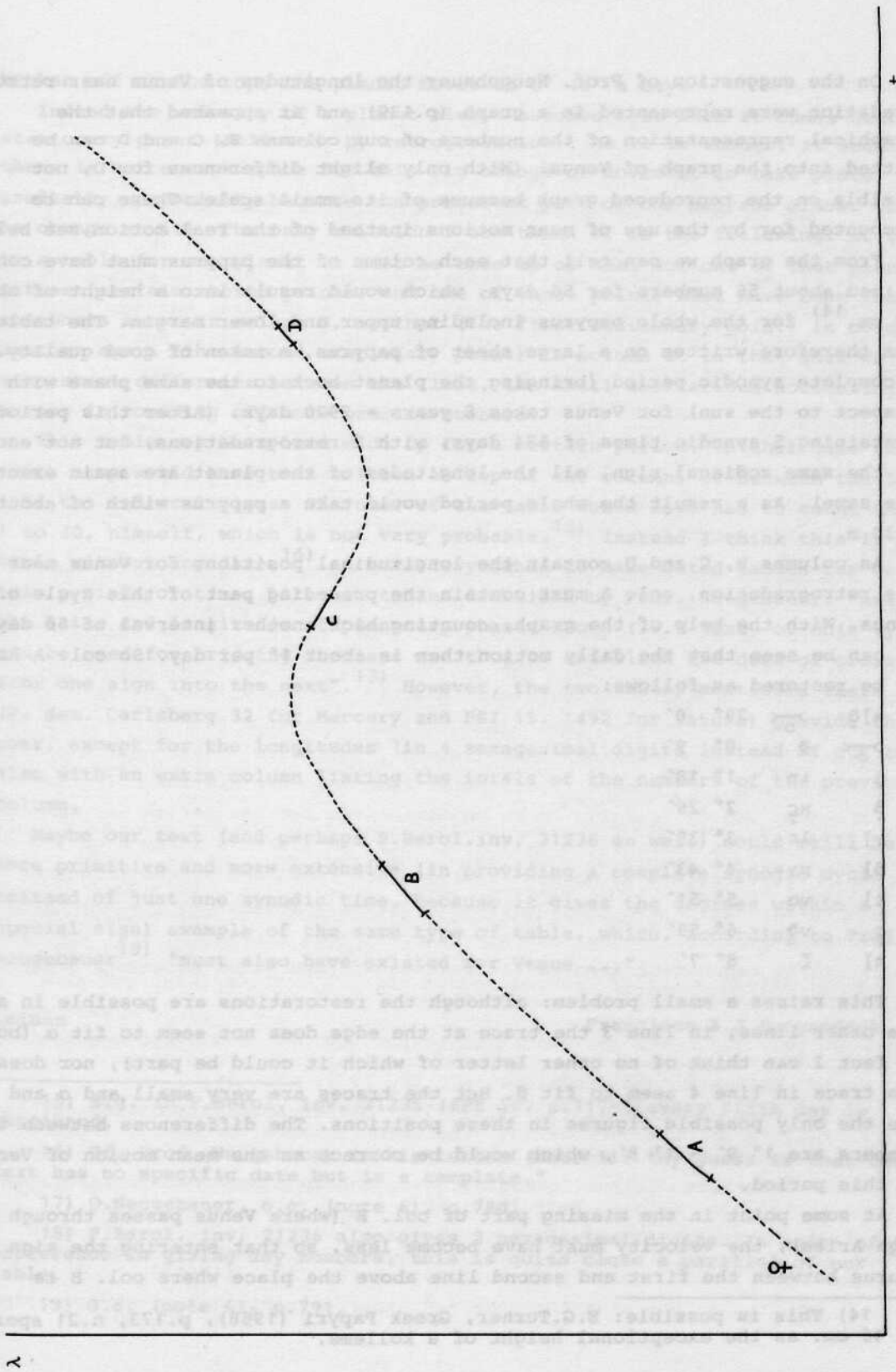
11) O.Neugebauer, o.c. (note 2) and cf. o.c. (note 6), p.946-8.

12) B.Tuckerman, Planetary, Lunar, and Solar Positions. 601 B.C. to A.D. 1 (1962), p.14.

13) O.Neugebauer, o.c. (note 6), Part One, p.193 (representing the numbers Ptolemaeus used in his Almagest).



Behaviour of Venus near retrogradation

On the suggestion of Prof. Neugebauer the longitudes of Venus near retrogradation were represented in a graph (p.139) and it appeared that the graphical representation of the numbers of our columns B, C and D can be fitted into the graph of Venus! (With only slight differences for D, not visible on the reproduced graph because of its small scale. These can be accounted for by the use of mean motions instead of the real motion, see below).

From the graph we can tell that each column of the papyrus must have contained about 56 numbers for 56 days, which would result into a height of about 38 cm.[14] for the whole papyrus including upper and lower margin. The table was therefore written on a large sheet of papyrus, a token of good quality. A complete synodic period (bringing the planet back to the same phase with respect to the sun) for Venus takes 8 years = 2920 days. (After this period, containing 5 synodic times of 584 days, with 5 retrogradations, but not each in the same zodiacal sign, all the longitudes of the planet are again exactly the same). As a result the whole period would take a papyrus width of about 1.30 m.

As columns B, C and D contain the longitudinal positions for Venus near its retrogradation, col. A must contain the preceding part of this cycle of Venus. With the help of the graph, counting back another interval of 56 days, it can be seen that the daily motion then is about 1° per day. So col. A has to be restored as follows:

1	κ]ϑ̣	♑	29°	0′
2	♑	ϑ	0°	9′
3	ϛ̣	ιη	1°	18′
4	β̣	κϛ̣	2°	26′
5	γ]	λε	3°	35′
6	δ]	μγ	4°	43′
7	ε]	να	5°	51′
8	ϛ̣	νϑ	6°	59′
9	η]	ζ	8°	7′

This raises a small problem: although the restorations are possible in all the other lines, in line 3 the trace at the edge does not seem to fit α (but in fact I can think of no other letter of which it could be part), nor does the trace in line 4 seem to fit β. But the traces are very small and α and β are the only possible figures in these positions. The differences between the numbers are 1° 9′ - 1° 8′, which would be correct as the mean motion of Venus in this period.

At some point in the missing part of col. B (where Venus passes through the sign Aries), the velocity must have become less, so that entering the sign Taurus between the first and second line above the place where col. B is

14) This is possible: E.G.Turner, Greek Papyri (1968), p.173, n.21 speaks of 46 cm. as the exceptional height of a kollema.

broken off at the top, the planet moves at 0° 44′ a day.

Indeed the velocity of a planet always becomes less when it comes near its stationary point (followed by retrogradation). As it is though, it seems there is not enough space for this big change of movement to take place gradually, especially because the preserved part of the papyrus almost shows no change at all. The only solution I can think of is the following: if this is a table for one planet it must be made up of mean motions of that planet between certain chosen points, and one of those points must have been reached somewhere above in column B, another (the first stationary point) in column C, another again (the second stationary point) in column D. In that case we have a constant difference between the lines, the small aberrations accounting for errors in rounding off more precise numbers.

This table may have been made up for a certain period. In that case the month name would have been written on top of the column, or between the lines like the zodiacal signs. The user of the table would have had to count the days, 1 to 30, himself, which is not very probable.[15] Instead I think this is a table without any date,[16] an auxiliary table to make dated tables for certain periods of time, like the tables described by Prof. Neugebauer: "assuming the dates and longitudes of planetary phases known (...) texts of this type can be used for bridging the gaps and thus to establish the date of crossing from one sign into the next".[17] However, the two tables mentioned there (P. dem. Carlsberg 32 for Mercury and PSI 15. 1492 for Saturn) provide the user, except for the longitudes (in 4 sexagesimal digits instead of our two),[18] also with an extra column listing the totals of the numbers of the previous column.

Maybe our text (and perhaps P.Berol.inv. 21236 as well) could still be a more primitive and more extensive (in providing a complete synodic cycle instead of just one synodic time, because it gives the degrees within a special sign) example of the same type of table, which, according to Prof. Neugebauer[19] "must also have existed for Venus ..."

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15) E.g. in P.Berol. inv. 21236 (ZPE 20, p.117-8)every fifth day is mentioned.

16) Cf. Prof. Neugebauer in his letter (note 1): "My guess is that the text has no specific date but is a template."

17) O.Neugebauer, o.c. (note 6), p.790.

18) P.Berol. inv. 21236 also gives 2 sexagesimal digits. In spite of the difference in giving day numbers, this is quite close a parallel of our table.

19) O.c. (note 6), p.791.