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a cura di
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1673. ASTRONOMICAL TABLE: TEMPLATE FOR SATURN

inv. 4249 *recto* Tav. XVII
? cm 12,1 x 19,8 II/III[p]

Recto of this papyrus (cf. **1667** for the *verso*, a glossary to Book I of the *Iliad*) bears the remains of a single astronomical table of the variety called "template"[1], written in neat informal capitals typical for numerical tables from the second and third centuries of our era. A template contains a list of numbers in sexagesimal (base 60) notation that represent a heavenly body's day-by-day progress in degrees of longitude starting from a particular stage in the body's periodic pattern of motion. The template was meant to be used together with a separate "epoch table" listing the dates and the body's longitudes computed for successive "day zeros" to obtain the longitude for any given date[2].

The lower portion of two sets of three columns is preserved in one large fragment and two small detached strips, one bearing part of i 5 and the other what survives of iv 6; the main fragment has approximately 4 cm bottom margin[3]. In each set of columns, the middle one, indicating the number of days elapsed since epoch (cols. ii continuing into v, with the number inscribed every fifth line only), is flanked by a column to its left (i continuing into iv) giving the number of degrees travelled since the preceding day, and a column to its right (iii continuing into vi) giving the total number of degrees travelled since epoch. The daily motion decreases from line to line by constant steps of exactly 0;0,4,37°, and if continued one line after the last tabulated line (iv 40), would reach exactly zero on the 119th day since epoch[4]. The total progress on days 118 (and 119) is approximately 9°. This information suffices to identify this as a template for the motion of Saturn covering the interval from its first morning visibility to its first (morning) stationary point. Twenty lines of table are lost above col. i; hence the total height of the table, excluding margins, would have been about 21 cm, accommodating up to 60 tabular

[1] Jones, *Astronomical Tables*, pp. 311-315.

[2] Jones, *Astronomical Tables*, pp. 305-310.

[3] Additionally there are four tiny fragments with negligible traces of numerals or ruling, and three with blank rectos.

[4] We employ the standard notation for sexagesimal numerals, according to which a semicolon separates the whole number from the first fractional place, and commas separate the fractional places. When, as here, the quantities are degrees, the first two fractional places are respectively minutes and seconds.

rows, and the full height of the papyrus was perhaps roughly 30 cm. The preserved contents of the *Iliad* glossary on the *verso* appear to imply that the original roll extended significantly to the left of the table on the *recto*; thus we may hypothesize a series of tables, likely including others of the template type for Saturn or other planets.

The table is written within a framework of ruled lines. To the immediate left of col. i is a double vertical ruling, with the line to the left in black ink and the one to the right in red. This ruling apparently marked the left margin of the entire table. Single vertical rulings in red appear to the right of cols. i, ii, v, and vi. Between cols. iii and iv are two red rulings about as far apart (ca. 1 cm) as the rulings framing col. ii, but nothing seems to have been written anywhere in this space. Horizontal red rulings cross the table at intervals of roughly 1 cm but with noticeable irregularities of spacing. The bottom of the table is marked by a horizontal black ruling, which was reinforced with an additional horizontal stroke or strokes at col. vi, apparently to indicate deletion of a row of zeros that does not belong in this place. In writing the columns of numerals, the inscriber of the table used the vertical rulings to align the left margin of each column, while the right margins are irregular and sometimes cross the next ruling. He appears to have largely ignored the horizontal rulings, sometimes fitting two lines, sometimes three between them, and sometimes superimposing a line on a ruling. Occasional isolated scribal errors show that the numerals were copied from an exemplar rather than being computed in the process of writing the table out. The column of daily motions was apparently copied first, and thereafter the columns for day numbers and total progress, without taking care to keep the rows of the table lined up so that the daily motions can be one line or more too high or low relative to the other numerals that properly belong to the same line. In our transcription, the proper horizontal alignment has been restored, and the horizontal rulings have been omitted.

The present template table for Saturn is a welcome addition to the corpus of astronomical tables in papyri that reflect Greek knowledge of Babylonian mathematical astronomy. According to one of the Babylonian mathematical models for predicting the phenomena of Saturn, known as System A, the ecliptic is divided into two unequal zones: a "slow" zone of 200° from Capricorn 10° to Gemini 0°, and a "fast" zone of 160° from Gemini 0° to Capricorn 10°[5]. In each zone the planet's longitudinal progress over an entire synodic period from, say, first visibility to first visibility as well as the duration of the synodic period are assumed to be constants, smaller in the

[5] Neugebauer, *Mathematical Astronomy*, p. 437.

slow zone and larger in the fast zone. Similarly, the longitudinal progress in the subdivisions of the synodic period, for example the interval from first visibility to first station, was assumed to be constant for each zone[6]:

fast zone: 9° from first visibility to first station
slow zone: 7;30° from first visibility to first station

Our template obviously describes the daily motion during this interval on the condition that Saturn is in its fast zone.

The pattern of numbers in the template was evidently based on the following assumptions: (1) the total progress from first visibility to first station is approximately 9°; (2) the time interval from first visibility to first station is approximately 118 days, i.e. approximately four lunar months[7]; (3) the daily motion diminishes by constant decrements to zero; and (4) all calculations are to be performed exactly using numbers having three fractional sexagesimal places. The sum of n numbers diminishing by constant decrements d to zero is:

$$S(n) = dn\,(n + 1)/2$$

Hence setting $S(118)$ to 9°, we find:

$$d = 0;0,4,36,53,\ldots^\circ \approx 0;0,4,37^\circ$$

The initial daily motion for day 1 is thus $118d$ = 0;9,4,46°, and this is obviously also the progress since epoch for this day. The remainder of the table is generated simply by diminishing the daily motion from line to line by d and keeping a running total.

Two other templates for Saturn have previously turned up in papyri. XV **1492** covers the entire synodic period of the planet in 378 days, and represents a pattern of motion that approximates a mean between the fast and slow zones of the Babylonian System A. Despite this difference, it shares with **1673** the assumption that the time from first visibility to first station is 118 days. P.Oxy. LXI 4166, on the other hand, is like **1673** in being a template for a specific subdivision of the synodic period, in this instance from second station to last visibility, which should be approximately a temporal mirror-image of the interval from first visibility to first station. P.Oxy. LXI 4166 is intended for the slow zone of the System A model, assuming a progress of approximately 7;30° in 110 days.

[6] Neugebauer, *Mathematical Astronomy*, pp. 439-440.

[7] For this parameter in Babylonian sources see Neugebauer, *Mathematical Astronomy*, p. 440, formula 11b.

	i				ii	iii			
	[⟌	ζ	λβ	κϛ]		β̣	νδ̣	λ̣	[λ]ϛ
	[⟌	ζ	κζ	μθ]		γ	α	νη	κε
	[⟌	ζ	κγ	ιβ]		γ	θ	κα	λζ
	[⟌	ζ	ιη	λε]		γ	ιϛ	μ	ιβ
5	[⟌	ζ	ι]χ	νη	[κε]	[γ]	κγ	νδ	ι
	[⟌	ζ	θ	κα]		[γ	λ]α	γ	λα
	[⟌	ζ	δ	μδ]		γ	λη	η	ιε
	[⟌	ζ	⟌	ζ]		γ	με	η	κβ
	[⟌	ϛ	νε	λ]		γ	νβ	γ	νβ
10	[⟌	ϛ	ν	ν]χ	λ	⟨γ⟩	νη	νδ	με
	[⟌	ϛ	μϛ]	ι̣ϛ̣		δ	ε	μα	α
	[⟌	ϛ]	μ̣α	λθ		δ	ι̣β̣	κβ̣	μ
	[⟌	ϛ]	λ̣ζ	β̣		δ	ι̣η	ν̣θ̣	μ̣β̣
	[⟌	ϛ	λ]β̣	κ[ε]		δ̣	κ̣ε̣	λ̣β̣	[ζ]
15	[⟌	ϛ]	κ]ζ	μη̣	λ̣ε̣	⟨δ⟩	λ̣α	[νθ	ν]ε̣
	[⟌	ϛ	κγ	ι]α̣		δ	λ̣η̣	κ̣γ	ϛ̣
	[⟌	ϛ	ιη	λ]δ		δ	μδ̣	μ̣α̣	μ̣
	[⟌	ϛ	ιγ]	νζ		δ	ν̣	νε	λ̣ζ
	[⟌	ϛ	θ	κ]		δ̣	νζ	δ	νζ
20	[⟌]	ϛ̣	[δ	μ]χ	μ	ε	γ	θ	μ
	⟌	ϛ	⟌	ϛ		ε	θ	θ	μϛ
	⟌	ε	νε	κθ		ε	ιε	ε	ιε
	⟌	ε	ν	νβ		ε	κ	νϛ	ζ
	⟌	ε	μϛ	ιε		ε	κϛ	μβ	κβ
25	⟌	ε	μα	λη	με	ε	λβ	κδ	⟌
	⟌	ε	λζ	α		ε	λη	α	α
	⟌	ε	λβ	κδ		ε	μγ	λγ	κε
	⟌	ε	κζ	μζ		ε	μθ	α	ιβ
	⟌	ε	κγ	ι		ε	νδ	κδ	κβ
30	⟌	ε	ιη	λγ	ν	ε̣	νθ	μβ	νθ
	⟌	ε	ιγ	νϛ		[ϛ	δ]	ν̣ϛ	να
	⟌̣	ε̣	θ̣	ιθ		[ϛ	ι	ϛ	ι]
	[⟌	ε]	δ	[μβ]		[ϛ	ιε	ι	νβ]
	[⟌	ε	⟌	ε]		[ϛ	κ	ι	νζ]
35	[⟌	δ	νε	κη]	[νε]	[ϛ	κε	ϛ	κε]
	[⟌	δ	ν	να]		[ϛ	κθ	νζ	ιϛ]
	[⟌	δ	μϛ	ιδ]		ϛ	λ̣[δ	μγ	λ]
	[⟌	δ	μα	λζ]		[ϛ]	λ̣[θ	κε	ζ]
	[⟌	δ	λζ	⟌]		[ϛ]	μ̣[δ	β]	ζ̣
40	⟌̣	[δ	λβ	κγ]	ξ	[ϛ]	μ̣[η	λ]δ	λ

30 iii : νθ *l.* νε

	iv				v	vi			
					– – – –				
6	[‾	β	μ]α	λε		[η	ιδ	κϛ	μβ]
					(rows 7-21 lost)				
	̣	[α	κζ	μγ]	[ρ]	[η	μζ	δ	ι]
	̣	[α	κγ	ϛ]		[η]	μ̣[η	κζ	ιϛ]
	‾	α̣	[ιη	κθ]		η̣	[μθ	με	με]
25	‾	α̣	[ιγ	νβ]		η	ν	[νθ	λζ]
	‾	α	[θ]	ιε		η	νβ	[η	νβ]
	‾	α̣	δ	λη	ρε	η	νγ	ι[γ	λ]
	‾	α̣	‾	α		η	ν[δ	ιγ	λα]
	‾	‾	νε	κ̣[δ]		η	ν[ε	η	νε]
30	‾	‾	ν	μζ		η	ν[ε	νθ	μβ]
	‾	‾	μϛ	ι		η	νε	[με	νβ]
	‾	̣	μα	λγ	ρι	η	νζ	[κζ	κε]
	‾	̣	λ̣[ϛ]	νϛ		η	νη	[δ	κα]
	‾	̣	[λβ	ιθ]		η	νη	λ̣[ϛ	μ]
35	‾	[‾	κ]ζ	μ̣β		η	ν⟨θ⟩	δ	[κβ]
	‾	̣	κ̣γ	[ε]		η	νθ	κ[ζ	κζ]
	‾	‾	ι̣η	[κη]	ριε	η	νθ	μ[ε	νε]
	‾	̣	[ι]γ	[να]		η	νθ	ν̣[θ	μϛ]
	‾	[‾]	θ̣	[ιδ]		θ	‾	[θ	‾]
40	‾	[‾	δ	λζ]		θ	‾	ι[γ	λζ]
						⟦‾	‾	[‾	‾]⟧

31 vi : νε *l.* νϛ 41 vi crossed out or written along bottom ruling

	i				ii	iii				
	[0	7	32	26]		2	54	30	[3]6	
	[0	7	27	49]		3	1	58	25	
	[0	7	23	12]		3	9	21	37	
	[0	7	18	35]		3	16	40	12	
5	[0	7	1]3	58	[25]	[3]	23	54	10	
	[0	7	9	21]		[3	3]1	3	31	
	[0	7	4	44]		3	38	8	15	
	[0	7	0	7]		3	45	8	22	
	[0	6	55	30]		3	52	3	52	
10	[0	6	50	5]3	30	⟨3⟩	58	54	45	
	[0	6	46]	16		4	5	41	1	
	[0	6]	41	39		4	12	22	40	
	[0	6]	37	2		4	18	59	42	
	[0	6	3]2	2[5]		4	25	32	[7]	
15	[0	6]	2]7	48	35	⟨4⟩	31	[59	5]5	
	[0	6	23	1]1		4	38	23	6	
	[0	6	18	3]4		4	44	41	40	
	[0	6	13]	57		4	50	55	37	
	[0	6	9	20]		4	57	4	57	
20	[0]	6	[4	4]3	40	5	3	9	40	
	0	6	0	6		5	9	9	46	
	0	5	55	29		5	15	5	15	
	0	5	50	52		5	20	56	7	
	0	5	46	15		5	26	42	22	
25	0	5	41	38	45	5	32	24	0	
	0	5	37	1		5	38	1	1	
	0	5	32	24		5	43	33	25	
	0	5	27	47		5	49	1	12	
	0	5	23	10		5	54	24	22	
30	0	5	18	33	50	5	59	42	59	
	0	5	13	56		[6	4]	56	51	
	0	5	9	19		[6	10	6	10]	
	[0	5]	4	[42]		[6	15	10	52]	
	[0	5	0	5]		[6	20	10	57]	
35	[0	4	55	28]	[55]	[6	25	6	25]	
	[0	4	50	51]		[6	29	57	16]	
	[0	4	46	14]		6	3[4	43	30]	
	[0	4	41	37]		[6]	3[9	25	7]	
	[0	4	37	0]		[6]	4[4	2]	7	
40	0	[4	32	23]	60	[6]	4[8	3]4	30	

			iv			v			vi	
						– – – –				
6	[0	2	4]1	35			[8	14	26	42]

(rows 7-21 lost)

	0	[1	27	43]	[100]	[8	47	4	10]
	0	[1	23	6]		[8]	4[8	27	16]
	0	1	[18	29]		8	[49	45	45]
25	0	1	[13	52]		8	50	[59	37]
	0	1	[9]	15		8	52	[8	52]
	0	1	4	38	105	8	53	1[3	30]
	0	1	0	1		8	5[4	13	31]
	0	0	55	2[4]		8	5[5	8	55]
30	0	0	50	47		8	5[5	59	42]
	0	0	46	10		8	55	[45	52]
	0	0	41	33	110	8	57	[27	25]
	0	0	3[6]	56		8	58	[4	21]
	0	0	[32	19]		8	58	3[6	40]
35	0	[0	2]7	42		8	5⟨9⟩	4	[22]
	0	0	23	[5]		8	59	2[7	27]
	0	0	18	[28]	115	8	59	4[5	55]
	0	0	[1]3	[51]		8	59	5[9	46]
	0	[0]	9	[14]		9	0	[9	0]
40	0	[0	4	37]		9	0	1[3	37]
						⟦0	0	[0	0]⟧

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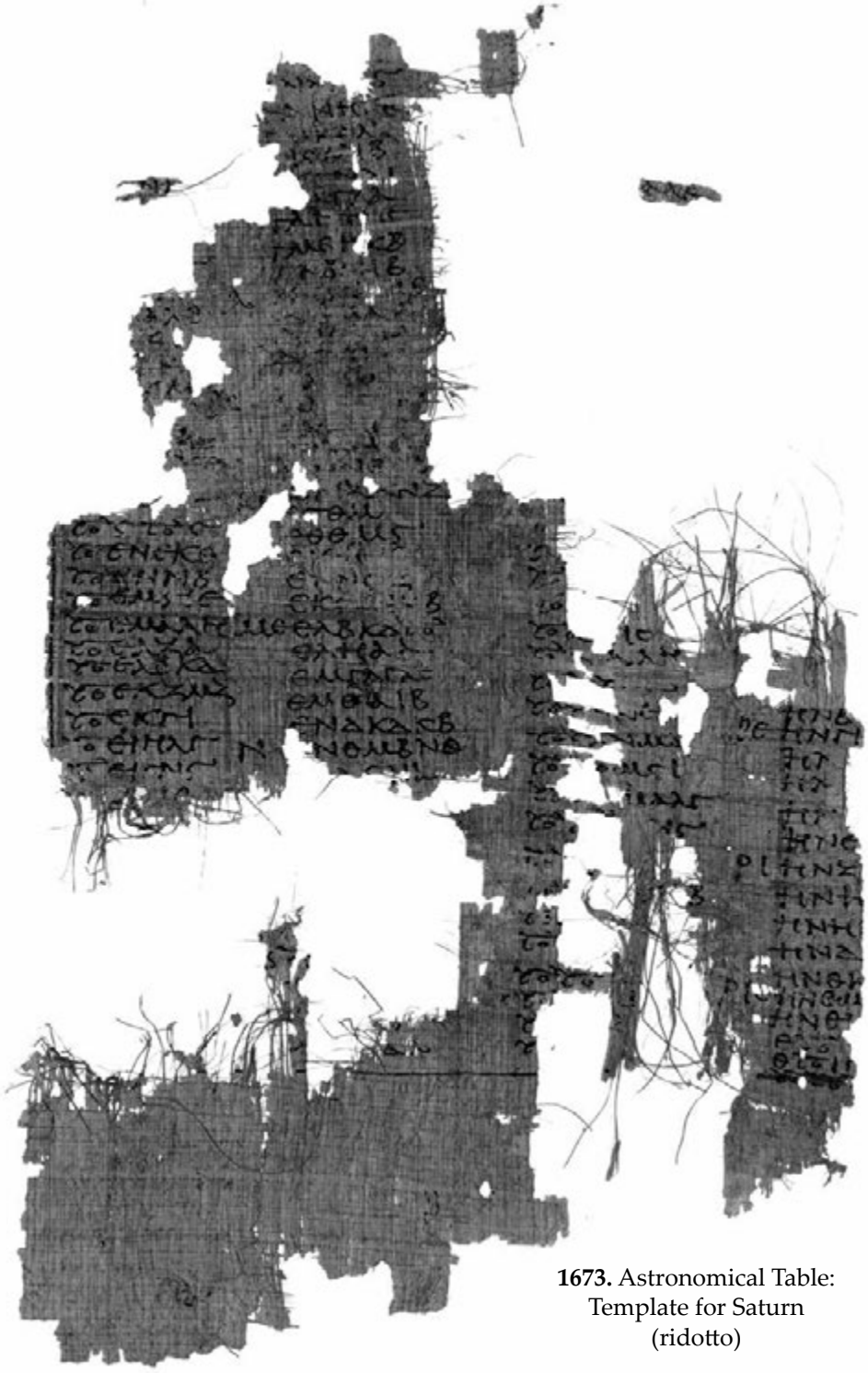

1673. Astronomical Table: Template for Saturn (ridotto)