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A Set of Astronomical Papyri Seen by Albert Rehm

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Among the *Nachlass* of Albert Rehm preserved in the Bayerische Staatsbibliothek (Munich) is a small folder catalogued as Rehmiana III/6 and labelled “Astronomischer Papyrus in München”.[1] The folder contains small loose sheets from a spiral-bound notebook, on which Rehm wrote notes on a set of seven Greek papyrus fragments, including facsimiles drawn carefully in pencil. Some of the sheets are enclosed in a printed document dated February 7, 1938, and one of Rehm’s notes begins with the date March 7, 1939. Probably the entire file dates from these years. It contains no indication of the collection to which the papyri belonged, and their present location is unknown. For the time being, therefore, Rehm’s copies are the only record of the papyri, though it may be hoped that their publication here will lead to the eventual rediscovery of the originals.

As we will see below, the fragments derive from at least three, and possibly five, distinct manuscripts of astronomical tables; they were probably found together and constitute what survived from an astrologer’s resources for calculating astronomical data such as the zodiacal longitudes of the planets.

Fragment 1.

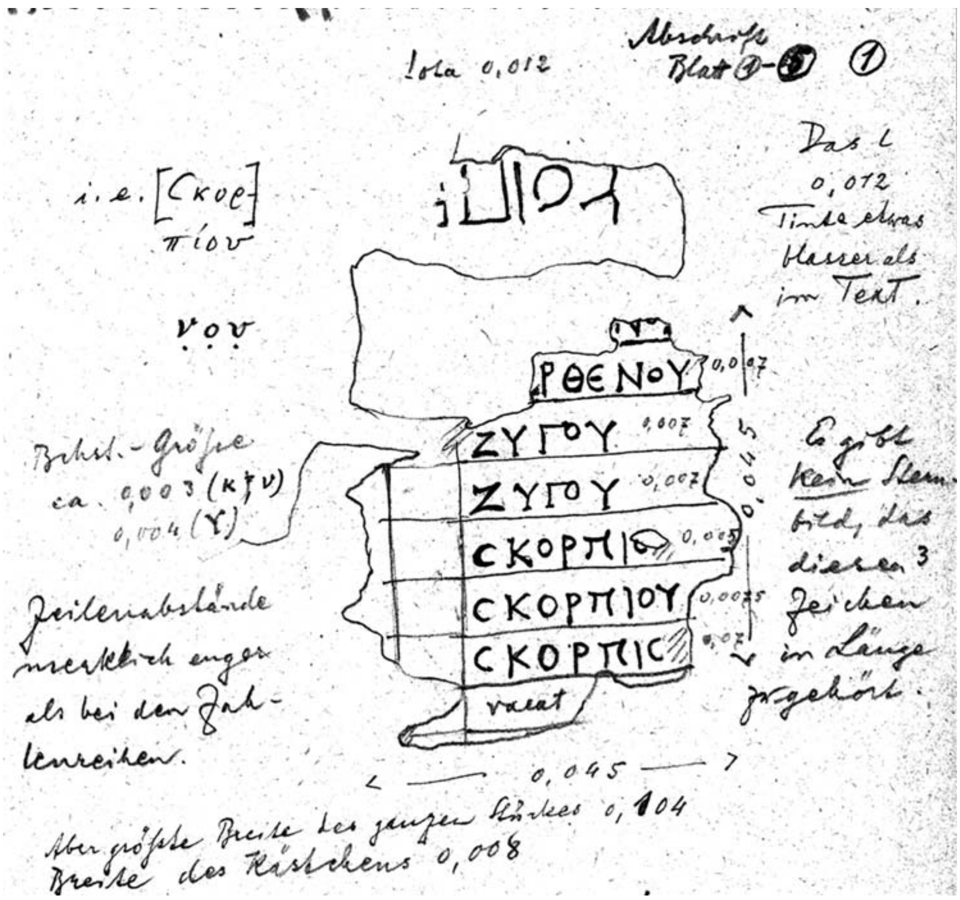

Fig. 1. Fragment 1, front, copy and notes by Albert Rehm from Rehmiana III/6

[1] For a catalogue of the Rehm *Nachlass* see Bayerische Nationalbibliothek n.d. I am grateful to the Bayerische Staatsbibliothek for their scans of Rehmiana III/6 and for permission to reproduce portions of them here.

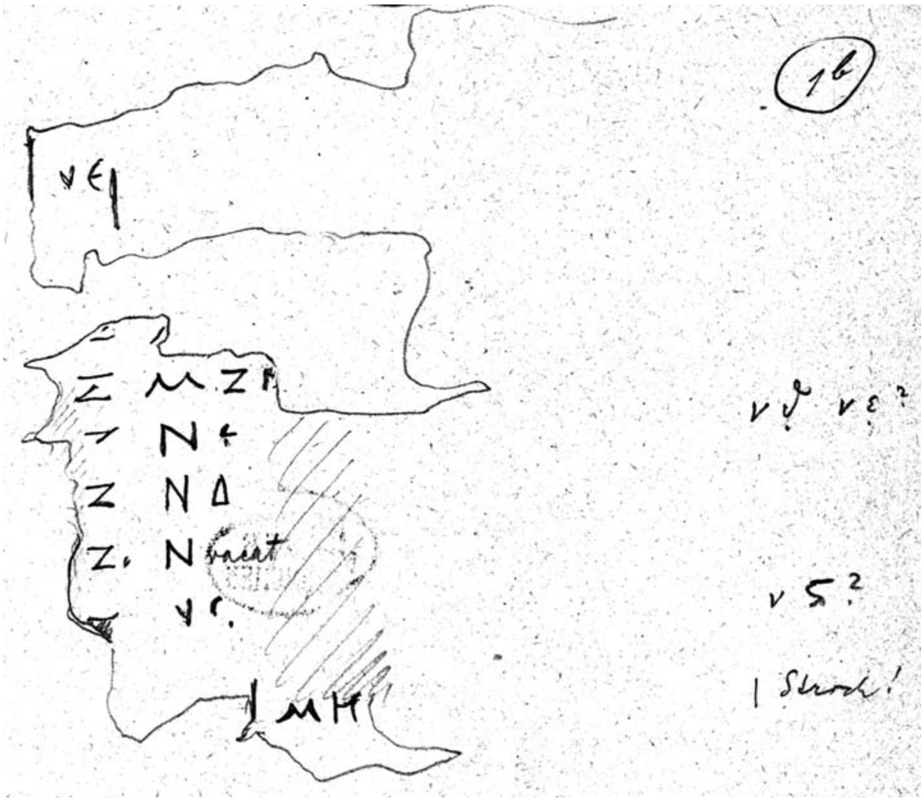

Fig. 2. Fragment 1, back

The incomplete outlines show that Rehm was reproducing only the inscribed parts of a larger piece of papyrus; the recorded dimensions 45 mm by 45 mm refer only to the nearly detached part bearing the ruled table on the front, whereas the entire papyrus had breadth 104 mm, height not recorded.[2]

The only inscribed column surviving on the front contains the names of the three consecutive zodiacal signs Virgo (twice), Libra (twice), and Scorpio (three times), followed by an apparently vacant row. Rehm evidently considered the possibility that this was part of a star catalogue similar to the catalogue in Ptolemy, *Almagest* Books 7–8, listing the longitudes of the stars composing each constellation; however, he notes that no constellation extends through parts of the three named zodiacal signs. Another possibility is that this is part of an Epoch Table, that is, a table listing successive occurrences of a phenomenon of a heavenly body such as the first visibility of a planet.[3] Epoch Tables usually had columns giving the computed dates of the phenomenon and the computed longitudes of the relevant heavenly body on those dates. The only heavenly body whose synodic phenomena progress by a number of degrees that could allow two or sometimes three consecutive occurrences in each zodiacal sign is Saturn, which progresses between 11° and 15° in each synodic period.

Rehm identified the writing in the strip of papyrus above the table as part of ΣΚΟΡΠΙΟΥ, written in taller letters (the iota reported as 12 mm in height), somewhat fainter ink, and mirror-reversed vertically, an oddity that he explained as offsets transferred from another inscribed surface.

The absence of ruling suggests that the table on the back was different from the one on the front. The letters in the upper strip (apparently ṆEI) could be part of a heading. The rows are probably numbers of degrees with sexagesimal fractions, all of them slightly less than 8 though it is difficult to identify a trend because of uncertainties in the readings. This could be a tabulation of daily longitudes, or a Template (daily progress in longitude since an epoch date), of a planet moving slowly.[4]

[2] Rehm gives no explicit indications of the directions of the fibers, but he appends the letter *b* to his fragment numbers to specify what he regards as the reverse side, and for fragments 6–7 the only side copied is what he calls the *Rückseite*.

[3] Jones 1999a, 305–310.

[4] For Templates see Jones 1999a, 311–314.

Fragments 2–4, front sides.

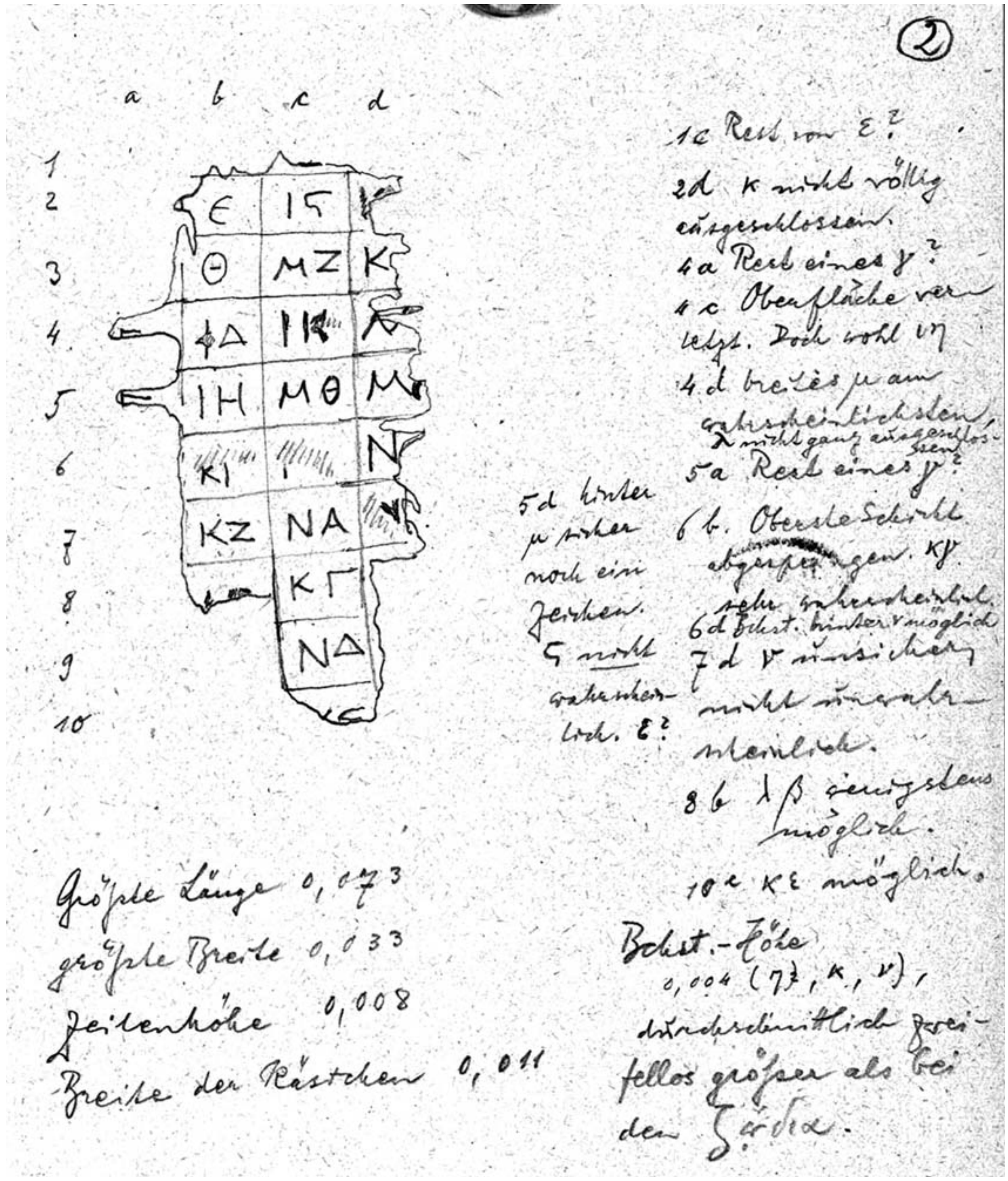

Fig. 3. Fragment 2, front

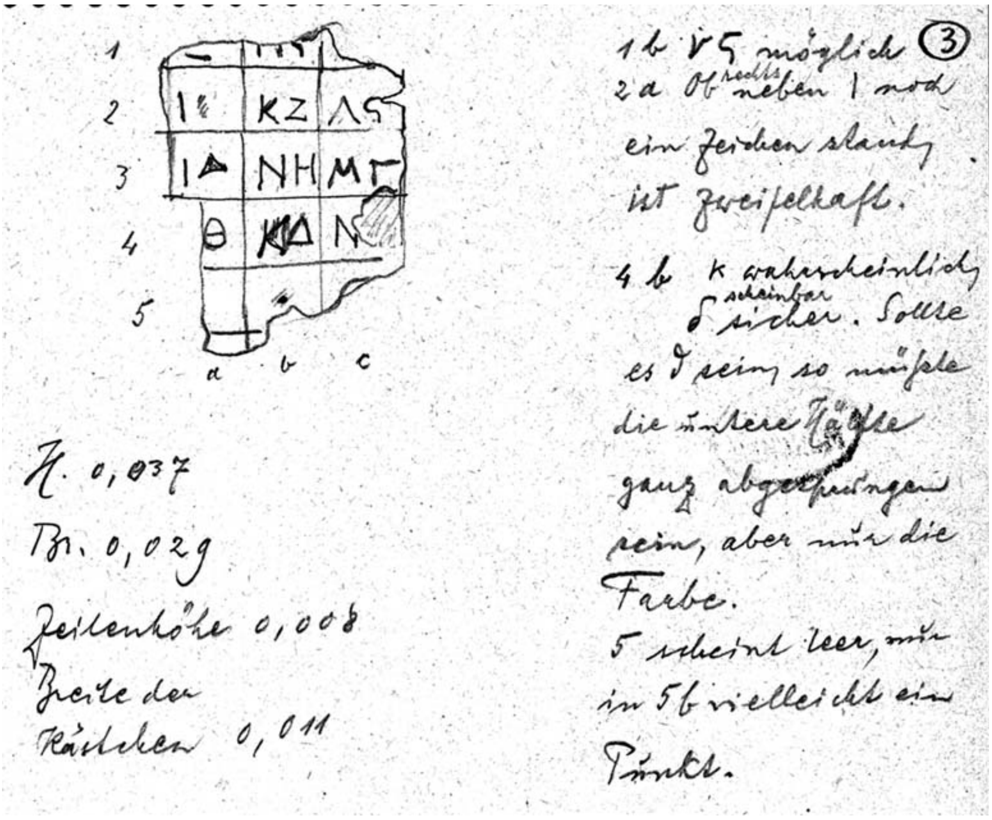

Fig. 4. Fragment 3, front

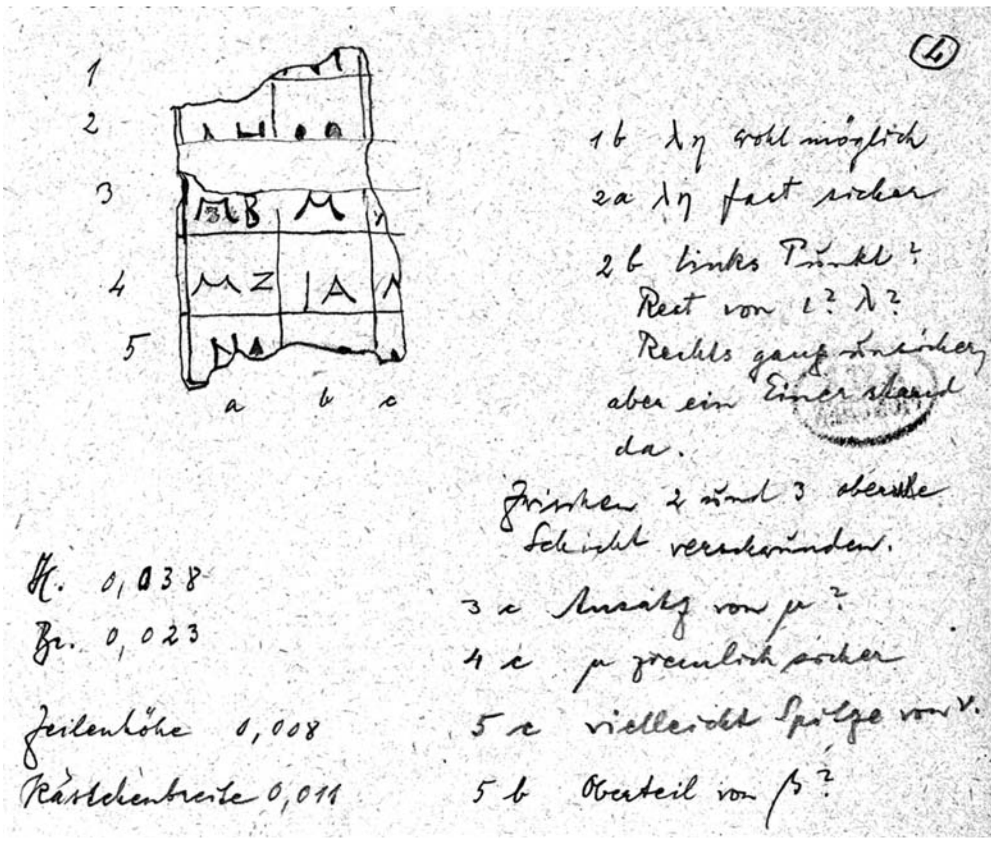

Fig. 5. Fragment 4, front

The dimensions of these fragments, which obviously belong to a single table, are respectively (fr. 2) 73 mm by 33 mm, (fr. 3) 37 mm by 29 mm, and (fr. 4) 38 mm by 23 mm. Rehm's notes show that he realized that each row represents a single quantity expressed sexagesimally, with the vertical rulings separating the sexagesimal places. Fr. 2 col. a is all that remains of the highest-order place, probably the units, so that Fr. 2 col. b and Frs. 3 and 4 col. a would be the sixtieths, and so forth for two further fractional places.

Rehm also recognized that the quantity increases row-by-row by a constant difference, which he estimated from the remains in fr. 2 to be 0;4,31,5, though in fr. 3 we can see that the last place must be about 7, not 5. In fact it is not difficult to establish that the quantities in fr. 2 and 4 form a continuous sequence, with fr. 4 topmost, then two missing rows, then fr. 2. Similarly, by extrapolating the sequence further we find that fr. 3 follows immediately after fr. 2, and that the numerals in fr. 3 col. a must have been 45, 50, 54, 59 (ΜΕ, Ν, ΝΔ, ΝΘ) though all that Rehm could see of the nus were single vertical strokes.

The numerals in fr. 2 col. a, lines 4 and 5 appear to be gammas. Supposing the units place in these rows to be simply 3, we have the quantity in line 5 as 3;18,49,4x where x represents an unknown numeral between 0 and 9, and with still more precision, we have fr. 3 line 2 as 3;50,27,36 and line 3 as 3;54,58,43. Dividing these last two quantities by the estimated constant difference, 0;4,31,7, we obtain respectively 51.002 and 52.002. We therefore hypothesize that the top row of the complete table, which we can call row 0, contained 0;0,0,0,0 and that all subsequent rows were simply the row number times the constant difference; this assumption narrows the possible range for the constant difference to between 0;4,31,7,45,53 and 0;4,31,7,46,9, or if we limit to four fractional sexagesimal places, specifically 0;4,31,7,46. The following reconstruction of rows 34 through 53 is based on this exact value, with digits in agreement with Rehm's readings underlined and digits in disagreement double-underlined. There can be no doubt that we have recovered the mathematical structure of the table.

row	*quantity*				
34	2	33	38	24	4
35	2	38	9	31	50
36	2	42	40	39	36
37	2	47	11	47	22
38	2	51	42	55	8
39	2	56	14	2	54
40	3	0	45	10	40
41	3	5	16	18	26
42	3	9	47	26	12
43	3	14	18	33	58
44	3	18	49	41	44
45	3	23	20	49	30
46	3	27	51	57	16
47	3	32	23	5	2
48	3	36	54	12	48
49	3	41	25	20	34
50	3	45	56	28	20
51	3	50	27	36	6
52	3	54	58	43	52
53	3	59	29	51	38

Fr. 3 line 5, which one would expect to hold row 54, appears to have been vacant, possibly indicating that the tabulated sequence ended here, having increased from zero to a quantity very near 4 in 53 rows.

I am able to offer only one plausible astronomical interpretation of this sequence, as a Template table describing the progress in longitude of a planet starting from one of the planet's stations, either the second station marking the end of retrograde motion, in which case the tabulated quantity would be added to the planet's longitude at the station, or the first station marking the beginning of retrogradation, in which case the tabulated quantity would be subtracted from the longitude at station. In either case, the table would represent the planet as moving with constant speed over the entire interval, rather than accelerating from zero speed at the station as one might have expected.

Comparison with Babylonian astronomical texts suggests that the sequence is in fact a Template for Saturn's motion from first station to acronychal (evening) rising, a synodic phenomenon that occurs slightly before the planet's opposition with the Sun. A procedure text (AO 6477 = ACT 801, rev. 9) specifies that the interval from first station to acronychal rising is 52 1/2 days, while the daily retrograde motion is given here as 0;5,4,24° per day for the part of the zodiac where Saturn's motion is fastest.[5] This text implies a total retrogradation of about 8° 24' for this region of the zodiac. On the other hand, a maximum retrogradation of 8° is attested in a table of computed longitudes (without dates) of Saturn's synodic phenomena, BM 36300+; if the motion from first station to acronychal rising was assumed to be half the retrogradation, this would give 4° total motion.[6]

An interesting feature of the sequence in the papyrus is that the assumed constant daily motion, 0;4,31,7,46°, is the exact product of 52 and 0;0,5,12,50,30. This means that the final total, 3;59,29,51,38°, could also be obtained as the sum of the first 52 values of a second-order sequence whose constant second difference is twice 0;0,5,12,50,30°, or 0;0,10,25,41°. That is, instead of treating the daily retrograde motion as constant, it could have been represented as starting at zero (for the station) and increasing by constant steps of 0;0,10,25,41°, and the total motion at acronychal rising would have been exactly the same. Very likely the precise total 3;59,29,51,38° was chosen to accommodate a template based on the assumption of a smooth acceleration, with all arithmetic still limited to numbers with four sexagesimal fractional places, which would of course have been slightly more laborious to compute.

Fragments 2 and 4, back sides.

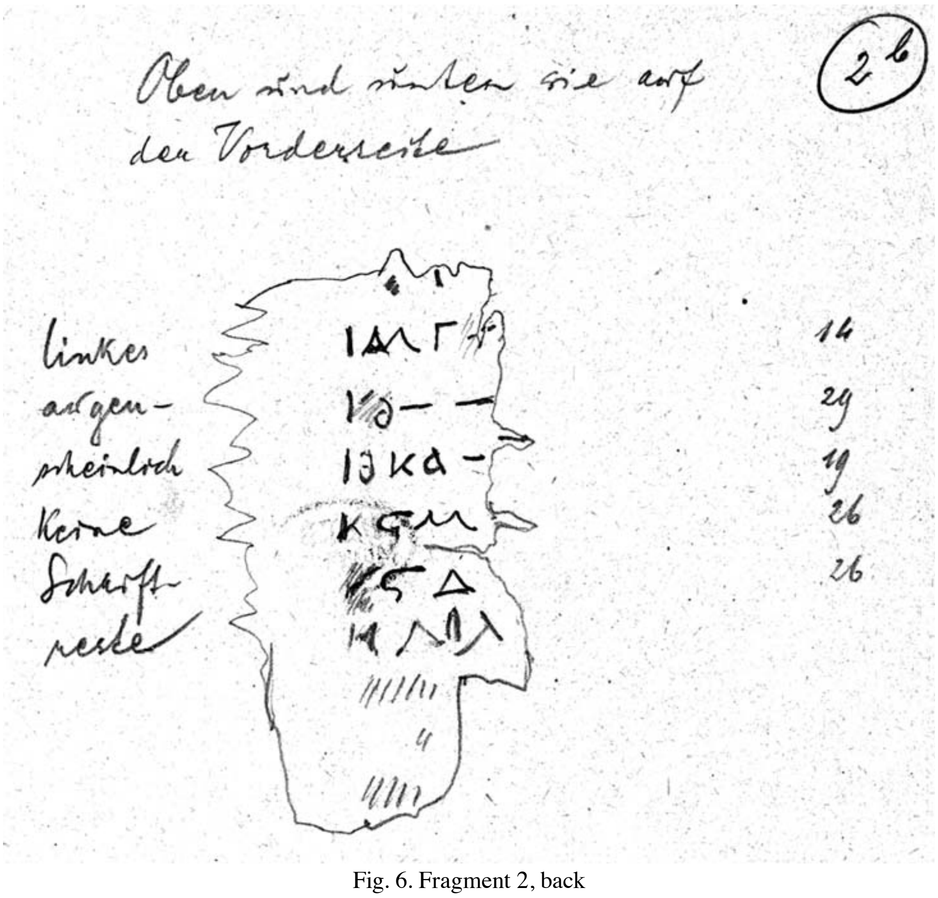

Fig. 6. Fragment 2, back

[5] Neugebauer 1955, 2.369.

[6] Aaboe–Sachs 1966, 3–4.

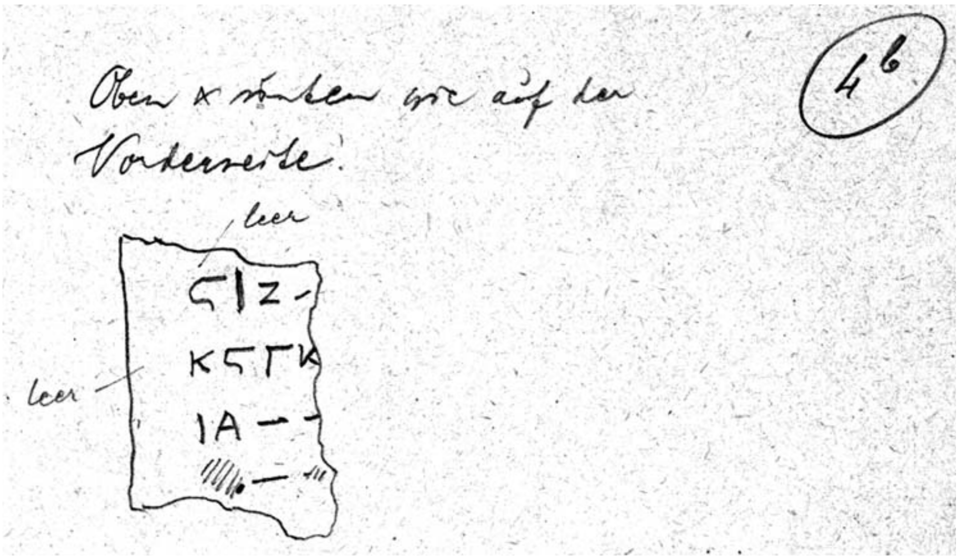

Fig. 7. Fragment 4, back

For the back of fragment 3, Rehm notes “nichts erkennbar”, probably meaning that he saw illegible (abraded?) traces.

The absence of ruling indicates that this was a different table from the Saturn Template on the front sides. The numerals are evidently sexagesimals, and Rehm’s horizontal strokes are probably the zero symbol employed in sexagesimal notation (typically a horizontal stroke above a small circle or dot, which Rehm may have missed).[7] Since the first numerals in each line are aligned by their left edges and Rehm states that there were no traces to their left, we may assume that these represent the units place of the tabulated quantity. Taking into account the known relative placement of fragments 2 and 4, the following seems to be the best transliteration possible from Rehm’s readings and notes (x represents uncertain digits):

row	*quantity*		
1	14	33	xx
2	29	0	0
3	19	21	xx
4	26	40	xx
5	26	4	xx
6	$8^?$	$32^?$	$30^?$
probably 3 rows lost or illegible			
10	6	17	xx
11	26	3	2x
12	11	0	0
13	xx	0	xx

The quantities could be degrees within zodiacal signs or calendar dates. In either case, one would expect a preceding column giving the names of the zodiacal signs or months. The zero fractions in rows 2 and 12 point to a Babylonian-style arithmetical method of computation. I have not, however, succeeded in finding a clear pattern in the sequence of numbers that would lead to a persuasive astronomical interpretation.

7 For forms of the Greek zero see Jones 1999b, 1.61–62.

Fragment 5

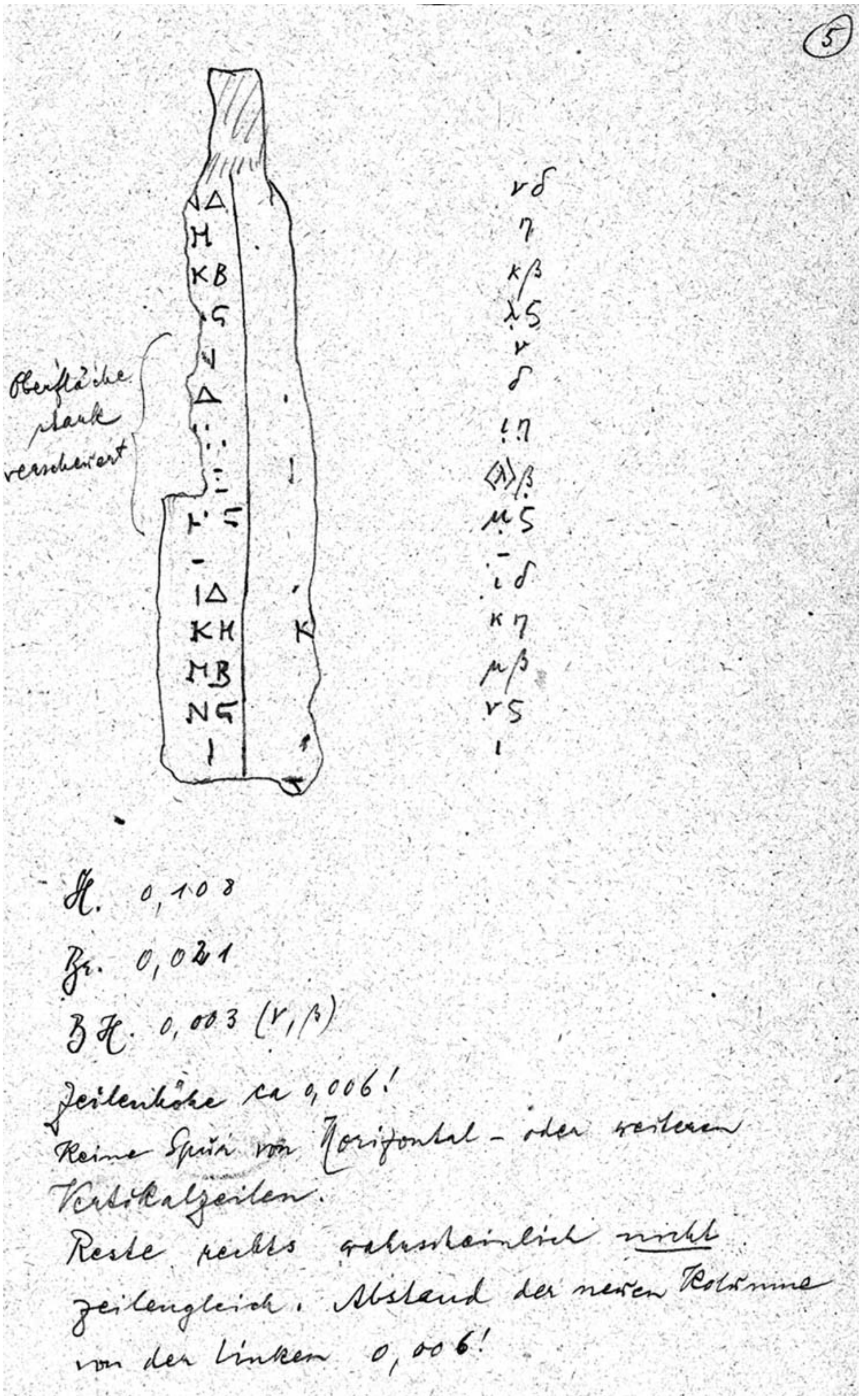

Fig. 8. Fragment 5, front

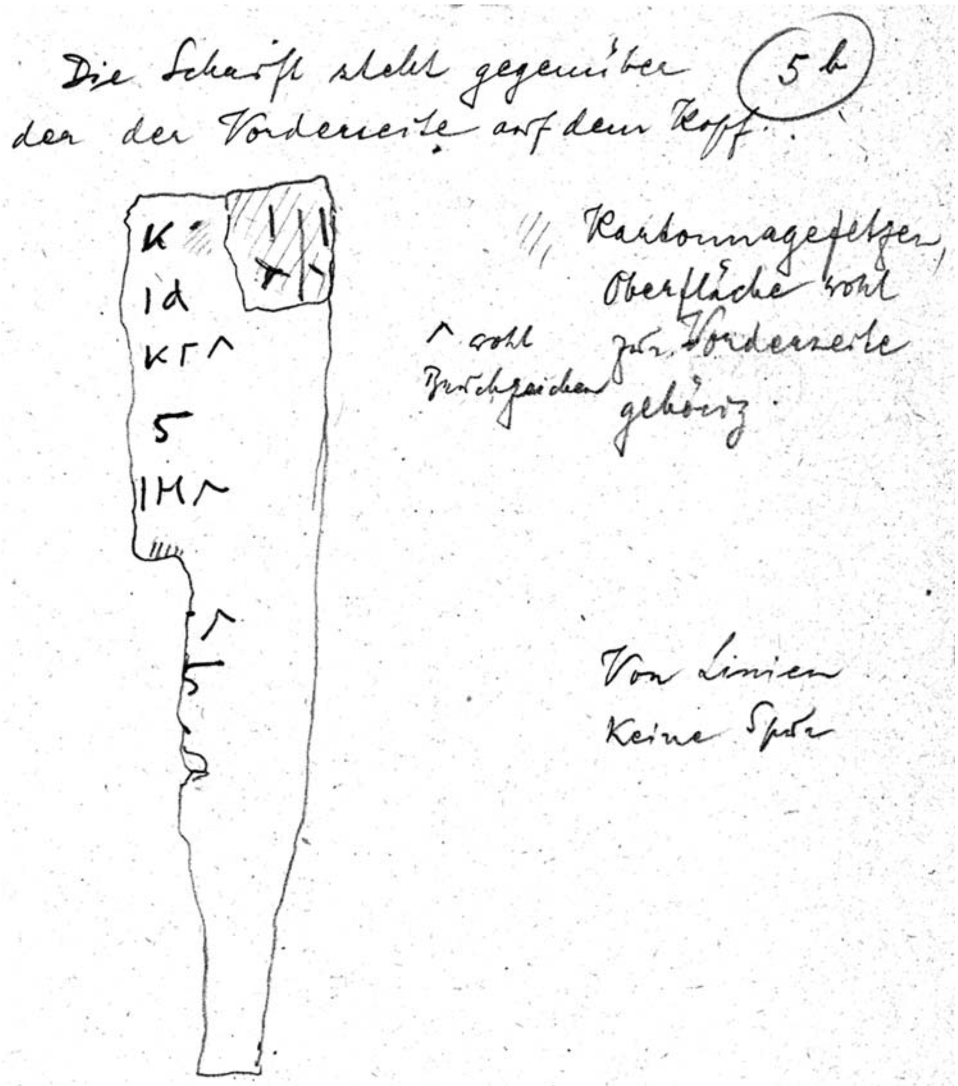

Fig. 9. Fragment 5, back

Recorded dimensions 108 mm by 21 mm. The writing on the back of this fragment is the other way up relative to the front, so this must have belonged to a different manuscript from fragments 1 and 2–4. The two sides again seem to preserve parts of different tables. Rehm's note "Kartonnagefetzen, Oberfläche wohl zur Vorderseite gehörig" presumably refers to the shaded area at the upper right of his drawing of the back. It is unlikely, however, that the fragment was really from cartonnage since the appearance of the hand in his copy gives no reason to date it (or the other fragments for that matter) earlier than the Roman period to which essentially all known Greek astronomical tables on papyrus belong.

Left of the ruling on the front is a column of numerals increasing line-to-line by a constant increment of 14 modulo 60, in other words, the lowest fractional place of a sexagesimal quantity probably increasing by constant steps. There is obviously no satisfactory basis for identifying the tabulated quantity. Right of the ruling, we perhaps have a column of names of zodiacal signs, in consecutive order, with legible initial letters of Ἰ(χθύσι), Κ(αρκίνῳ), and Σ(κορπίῳ).

The quantities on the back, so far as can be verified from what remains, increase line-to-line by increments of 12;30 (12 1/2) modulo 30, so they are probably calendar dates or degrees in zodiacal signs. The increments might, of course, include a whole number of 30-day months or 30° zodiacal signs in addition to the 12;30. Again this does not seem to be enough information to allow an identification.

Fragments 6–7

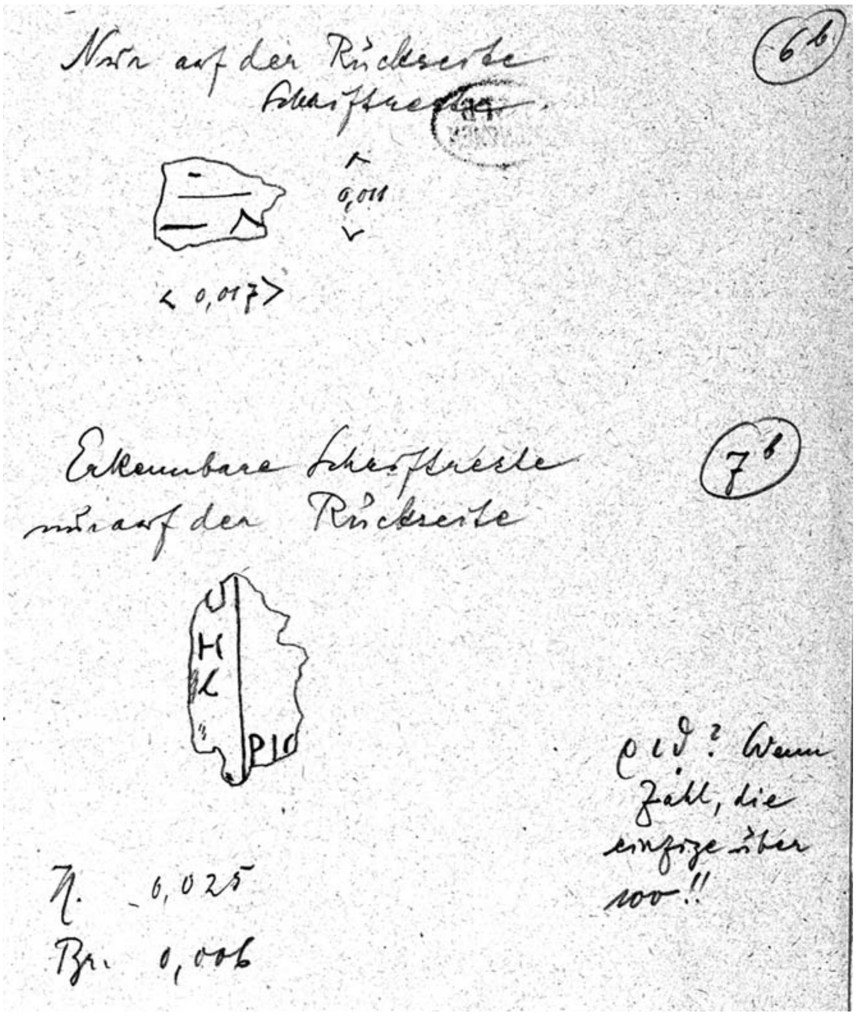

Fig. 10. Fragments 6 and 7, backs

Fragment 6 (11 mm by 17 mm) is utterly negligible.

The table of fragment 7 (25 mm by 16 mm), like that on the front of fragment 5, has a vertical but no horizontal ruling. Over the only two lines for which we have anything legible, there is an apparent line-to-line increase of 12. On the right side of the ruling, we have part of what appears to be the index (days since epoch) column of a Template table. In such index columns, the day count since epoch was typically recorded only in every fifth row. The numeral here would thus have been 125, not 129 as Rehm conjectured. Obviously too little is preserved to make identification of the heavenly body possible.

Bibliography

Aaboe, A., and A. J. Sachs. 1966. Some Dateless Computed Lists of Longitudes of Characteristic Planetary Phenomena From the Late-Babylonian Period. *Journal of Cuneiform Studies* 20, 1–33.

Bayerische Nationalbibliothek n.d. Albert Rehm (1871–1949) Klassischer Philologe: Rehmiana. https://bsbdok.digitale-sammlungen.de/general/item/bsbdok:116625/component/bsbdok:116624/Nachlassverzeichnis_Rehmiana.pdf.

Neugebauer, O. 1955. *Astronomical Cuneiform Texts*. 3 vols. London.

Jones, A. 1999a. A Classification of Astronomical Tables on Papyrus. In: N. M. Swerdlow (ed.), *Ancient Astronomy and Celestial Divination*, Cambridge, Mass. 299–340.

Jones, A. 1999b. *Astronomical Papyri from Oxyrhynchus*. 2 vols. in one. Philadelphia.

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