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Four procedure texts concerning Jupiter's latitude and synodic motion from Babylon

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Introduction

The four tablets published herein are of the type classified as 'procedure texts' by Neugebauer [1955] in ACT.[1] All four were dispatched to the British Museum by Rassam and BM 36680 and BM 36434 at least were probably were excavated by his team in Babylon;[2] unfortunately, nothing more is known of their provenance. The four texts contain System A schemes for computing the synodic phenomena of Jupiter, the subdivision of Jupiter's synodic arc, and Jupiter's latitude. There is significant overlap between the four texts and with ACT Nos. 813 and 814. Indeed, the grouping of sections on these texts is nearly identical.

Of particular interest among these procedure texts are the sections dealing with Jupiter's latitude. Until the late 1960s it had been thought that theories of planetary latitude were completely absent from Babylonian mathematical astronomy. However, Neugebauer and Sachs [1967], pp. 208–210 then published BM 37266, now known as Atypical Text F, which presents simple zodiacally fixed schemes for determining the latitude of Jupiter and Saturn.[3] Nevertheless, Atypical Text F was seen to be only a one-off investigation into planetary latitude by a single scribe until I published a preliminary study of the latitude sections of two of the texts published here, BM 36680 and BM 40659, and ACT Nos. 813 and 814 in Steele [2003]. Since then I have identified another tablet containing this material, BM 36434, and collated ACT Nos. 813 and 814. This has allowed a fuller reconstruction of the latitude scheme, confirming some of my earlier hypotheses.

In the first part of this paper I present an edition of the four texts. Following earlier authors I denote the synodic phenomena of the planets by the Greek letters shown in table 1. These editions are followed by a discussion of the reconstructed latitude procedure, which sadly still remains sketchy as none of the known sources is fully preserved.

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[1] All tablets are published by kind permission of the Trustees of the British Museum. I wish to thank Christopher Walker for facilitating my work on these tablets, Hermann Hunger for his helpful suggestions for improved readings, Mathieu Ossendrijver for providing me with a copy of his edition of BM 82824 in advance of publication, Norbert Roughton for making available his computer generated database of Late Babylonian planetary phenomena, and the referees for several useful comments. I remain responsible for any errors that remain in these editions. My work on these tablets was made possible by the award of a Royal Society University Research Fellowship.
[2] Reade [1986].
[3] See now Steele [2003].

Γ	First visibility
Φ	First station
Θ	Acronycal rising
Ψ	Second station
Ω	Last visibility

Table 1. Planetary Phenomena.

BM 36680 (80–6–17, 412)

Size: 5 × 8 cm.
Edges: No edges preserved.
Photographs: Figure 1.

Transliteration

Obv.

1' […] … […]
2' […] … 16? … ME? […]
3' […] … *šá* A … […]
4' […] x *a-na*? 30 *šá*? […] … […]
5' [… x,]30 GAR-GAR-*ma* 30 30? A-[RÁ] 30[+x …]
6' […] ˹x˺ ME 6 KI *ana ár-šú* LAL-*ma* UŠ ˹TA˺ […]
7' […] 14 ZI-*šú* TAB SIG *ù* 14[+x? …]
8' […] ME 12,30 ZI-*šú* U *ù* 12 […]
9' [… x,]45 GAR-GAR-*ma* 17,45 PAP-PAP TA […]
10' […] ˹6˺ KI *ina* NIM DU IGI TA IGI *ana* IGI x […]
11' […] 6 ME NI *šá* MU *ina* 6,42 ME-MEŠ TA IGI? [*ana* IGI…]
12' […] *u* ZI ŠÁR-ŠÁR *ina* 12 4,10 TAB *ina* 1,11 5 [LAL]
13' […] *šá* 30 6,15 BE IGI

14' [… TA 30 GÍR-TAB E]N 25 MAŠ-MAŠ 36 TAB TA ˹2˺[5 MAŠ-MAŠ EN ...]
15' […] *ana ár-šú* LAL-*ma* UŠ TA UŠ […]
16' [… 19,]30 KI DU UŠ 4,48 […]
17' [… MÚ]L-BABBAR *kàl* MU *ina* DAGAL *ma-l*[*ak* …]
18' […] ½ KÙŠ *i-šáp-pil* […]
19' [… MÁ]Š 16 GU 15,12 *zib* 1[4,24 …]

20' traces only

Rev.

1' […] EN[?] […] *ana* NUMUN[?] MU x […]

Translation

Obv.

1' […] … […]
2' […] … 16[?] … days[?] […]
3' […] … of Leo … […]
4' […] … to 30 of […] … […]
5' […] x,]30 add them together (to give) 30. 30 mul[tiplied by] 30[+x …]
6' […] x days 6 degrees of longitude it moves back and (it reaches second) station. From […]
7' […] (0;)14 is its velocity … and 14[+x …]
8' […] days (0;)12,30 is its velocity. … and 12 […]
9' […] x;]45 add them together and 17;45 is the total. From […]
10' […] 6 degrees of longitude in the morning(?) it moves forward and (it reaches) first visibility. From first visibility to first visibility x […]
11' […] ... 6(,0) days duration of the year, 6,42 days from first appearance [to first appearance …]
12' […] and compute the velocity. In 12 (years) add 4;10 (degrees). In 1,11 years [subtract] 5 (degrees) […]
13' […] concerning 30 (days), 6,15 if appearing.

14' […] From 30 Scorpio t]o 25 Gemini add 36. From 2[5 Gemini to …]
15' […] retrograde motion and (it reaches second) station. From (second) station […]
16' […] 19;]30 degrees it moves forward and (it reaches first) station. 4;48 […]
17' […] Ju]piter for the whole year. In the width of the pat[h …]
18' […] ½ cubit it is low […]
19' […] Capri]corn 16 Aquarius 15,12 Pisces 1[4,24 …]

20' traces only

Rev.

1' […] ... [...]

Figure 1. BM 36680 Obv. (left) and Rev. (right). (Copyright The British Museum)

Critical Apparatus

Obv. 7' I do not understand the significance of TAB SIG here. TAB has several known meanings including "add", "increasing (as in latitude)", or "positive (as in latitude)". Similarly SIG can mean "decrease", "negative (latitude)", and "Month III".[4] Perhaps TAB SIG refers to increasing negative latitude.

Obv. 8' I do not understand the significance of U here. Is U used as an alternative to SIG for "decreasing"? Or should we read the sign U as "10"?

Obv. 10' I do not understand *ina* NIM here. Has the scribe simply added it by mistake?

Obv. 11' Neugebauer [1955], p. 423 suggests that 6 ME NI *šá* MU is perhaps an expression for 6,0 *tithis* = 12 months or one year. Alternatively, we could read NI as ZAL meaning "it remains (invisible)" (cf. BM 36434 Obv. 5' below).

Obv. 13' Translation after Neugebauer [1955], p. 404.

[4] Neugebauer [1955], pp. 488 and 493.

Obv. 18' ½ KÙŠ: Initially I read *šú-ú* here (Steele [2003], p. 280). For the reading ½ KÙŠ, see below.

Rev. 1' *ana* NUMUN[?] MU: Perhaps part of a colophon to be read [I]NUMUM-MU as the name *Zēri-iddin*, but this seems unlikely as then there would be a very large unused space below this colophon on the tablet. Or perhaps the signs following the break are [...] ME[?] x MU (*ana* ME can mean "predict").

Commentary

Section 1: Obv. 1'–13'

Too little is preserved of the beginning of this section to make sense of. Beginning in line 6' we find a statement of the subdivision of Jupiter's synodic arc. Line 6' gives 6° for the interval between Θ and Ψ, in agreement with that found in the first part of ACT No. 813 Section 11 and known as applying to the fast arc of Systems A and A′. Velocities of 0;14° per *tithi* and 0;12,30° per *tithi* are mentioned in lines 7' and 8'. 0;12,30° per *tithi* is known as the velocity assigned to the stretch of the synodic arc from Ω to Γ on the slow arc of Systems A and A′. A velocity of 0;14° per *tithi* is plausible for the same stretch, but would imply a total synodic arc of 33;36° which is previously unattested. Perhaps 0;14° per *tithi* is rounded from 0;14,3,45° per *tithi*, which would be the expected velocity from Ω to Γ on the medium arc of System A′ (which has a synodic arc of 33;45°). Alternatively, 0;14 may be a scribal error for 0;15, which would be the expected velocity on the fast arc. However, I am unable to make sense of the remainder of these lines. The total 17;45° in line 9' is known to be the interval between Ψ and Ω on the slow arc of Systems A and A′. Line 10' gives an interval of 6° from Ω to Γ, known to apply to the slow arc. Thus it appears likely that this section is describing System A, with lines 6'–7' dealing with the fast arc and lines 8'–10' the slow arc. Lines 11'–13' duplicate ACT No. 813 Obv. I 3–5 (and the less well preserved ACT No. 814 Obv.(?) 4–5), except that the final 7 BE ŠÚ is missing in the present text. For commentary to these lines, see Neugebauer [1955], p. 404.

Section 2: Obv. 14'–19'

Although not separated by horizontal rulings, comparison with ACT No. 813 Sections 2–4 suggests that this section should probably be separated into three sections. Note, however, that the other duplicates, the beginning of ACT No. 814 Section 2, and Texts B and C here, similarly do not split up this section.[5] Lines 14'–16' (and probably the beginning of the missing part of line 17') duplicate ACT No. 813 Section 2 and the first three lines of ACT No. 814 Section 2 (obv.(?) 6-8) and, when complete, provided a full

[5] See my comments in Steele [2003], p 282.

description of the subdivision of the synodic arcs of System A.[6] For discussion of lines 17'–18', see below. Line 19' contains part of a list of zodiacal signs and numbers whose meaning is not known.[7] From the duplicates we can restore almost the whole list:

KI RÍN 12 ZI-*šú* 12,48 GÍR 13,[36 … MÁ]Š 16 GU 15,12 *zib* 14,24 ḪUN 13,36 MÚL 12,14 MAŠ-MAŠ UD-MEŠ

BM 36434 (80–6–17, 161)

Size: 7 × 4.5 cm.
Edges: Left edge preserved.
Photographs: Figure 2.

Transliteration

Obv.

1' ⌜x *ár-šú*⌝ [...]
2' *ma-lak šá ... ina* ⌜UŠ x⌝ [...]
3' KI RÍN 12 ZI-*šú* 12,48 ⌜GÍR⌝ [...]

4' 6,10 ALLA 6,20 MÁŠ 1,40 TAB ŠÚ *a-na* UŠ A-R[Á ...]
5' *ina* ALLA 27 ME ZAL IGI *ina* MÁŠ 32 ME ZAL IGI [...]

6' MÚL-BABBAR TA IGI-*šú ana* 30 ME 10 ZI-*šú* 30 ME 6,40 ZI ⌜x⌝ [...]
7' TA UŠ *ár-tú* 3,20 ZI-*šú* TA UŠ *ár-tú* 30$^{?}$ [...]

8' TA ⌜5,45 ALLA$^{?}$⌝ [EN] ⌜5,45⌝ [GÍR$^{?}$] ⌜30 TA 5,45 GÍR$^{?}$⌝ [...]
9' [...] ⌜x⌝ [...]

Rev.

1' ⌜3$^{?}$⌝ [...]
2' MU *ana* ⌜MU⌝ [...]

3' UD IGI *ana* UD IGI *šá* MÚL-BABBAR [...]
4' 11,3,20 *ki* TAB KI [...]
5' 32 KI *šá* DU ⌜x⌝ [...]
6' UD^{me} *šá* IGI-*ka* T[A ...]

7' [Z]I$^{?}$ GABA ⌜x x⌝ [...]

[6] See Neugebauer [1955], pp. 404–405 and 423.
[7] Neugebauer [1955], pp. 405 and 424; Steele [2003], pp. 281–282.

Translation

Obv.

1' … […]
2' path ... At […] station […]
3' place of Libra 12 is its velocity. 12,48 Scorpio […]

4' 6,10 Cancer. 6,20 Capricorn. 1;40 is the addition. Last visibility to the station multiply[?] […]
5' In Cancer it remains (invisible) 27 days (and then) first visibility. In Capricorn it remains (invisible) 32 days (and then) first visibility. […]

6' Jupiter, from its first visibility for 30 days (0;)10 is its velocity. 30 days (0;)6,40 is its velocity […]
7' From second station (0;)3,20 is its velocity. From second station 30 [days? …]

8' From 5;45 Cancer to 5;45 Scorpio: 30. From 5;45 Scorpio […]
9' […] … […]

Rev.

1' 3[?] […]
2' year by year […]

3' Day of first visibility to day of first visibility of Jupiter […]
4' 11;3,20 if increasing(?) … […]
5' 32 degrees of longitude of forward motion … […]
6' your days of first visibility. Fr[om …]

7' […] epact[?] […]

Critical Apparatus

Obv. 2' ...: The sign appears to be DIŠ followed by QU, but I can make no sense of such a reading.
Obv. 4' Instead of TAB ŠÚ *a-na* UŠ we could read TAB-*šú* and translate "1,40 is its addition. For the station multiply […]"

Commentary

Section 1: Obv. 1'–3'

See below.

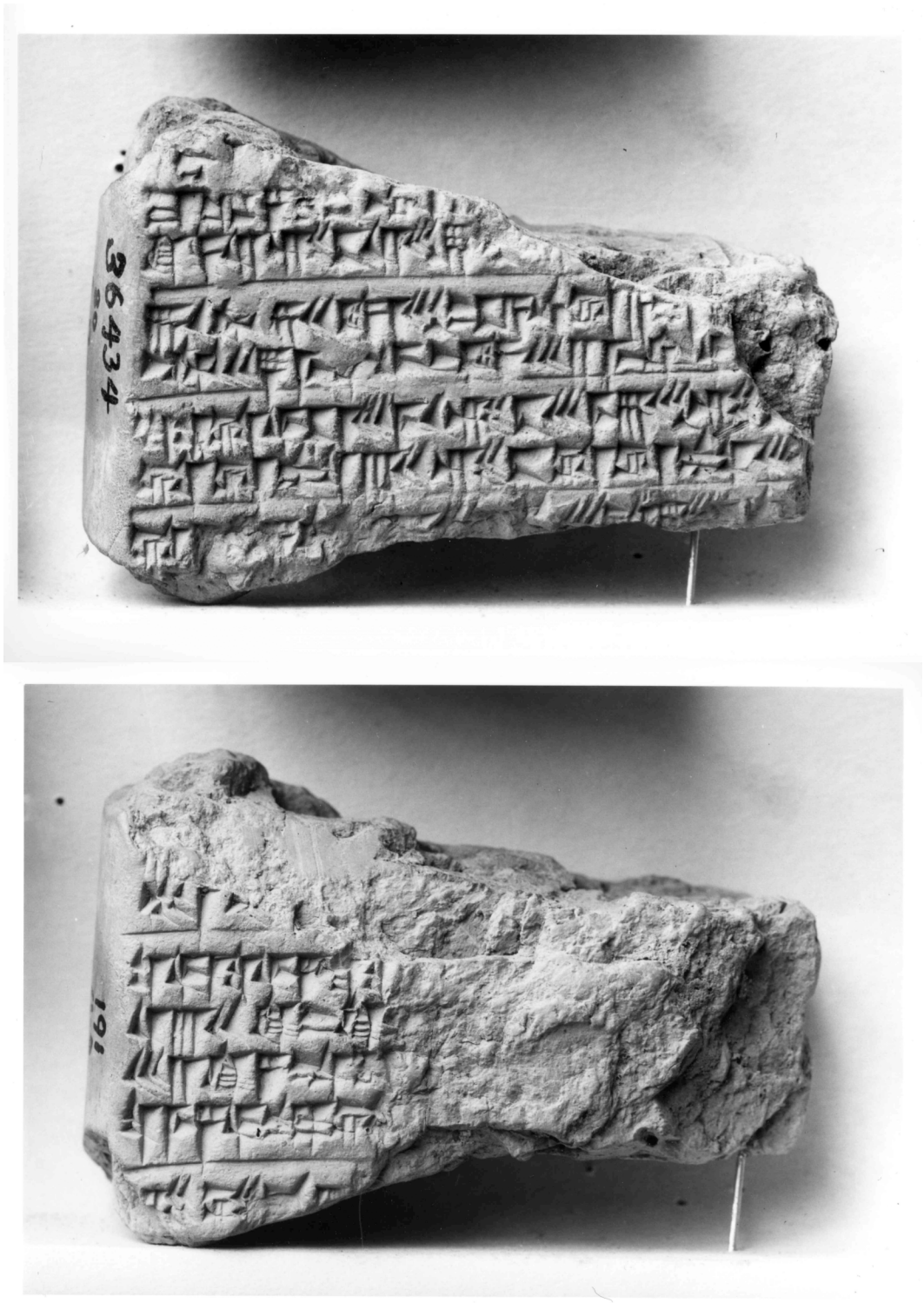

Figure 2. BM 36434 Obv. (top) and Rev. (bottom). (Copyright The British Museum)

Section 2: Obv. 4'–5'

Line 4' describes a linear zigzag function with maximum M = 6;20 in Capricorn, minimum m = 6;10 in Cancer, difference d = 0;1,40 per sign. Line 5' gives the duration of invisibility in days (= *tithis*?) for the zodical signs Cancer and Capricorn.[8] ACT No. 817 Section 1 describes a scheme where Jupiter is invisible for 27 days (= *tithis*?) in (probably) Cancer and Leo, and ACT No. 813 Section 11 states that Jupiter is invisible for 32 *tithis* in the fast arc and 27 *tithis* in the slow arc. In the present text it seems likely that the 27 and 32 days in Cancer and Capricorn are linked to the zigzag function described in the preceding line since the same zodiacal signs are mentioned. Assuming that line 5' also describes a zigzag function with maximum in Capricorn and minimum in Cancer, the difference d = 0;50 per sign is thirty times that of the difference in the function in line 4'. Figure 3 shows computed data for the duration of invisibility of Jupiter from Ω to Γ for six centuries starting in –600.[9] The solid line superimposed upon this data is the zigzag function from line 5'. In drawing this zigzag function it has been necessary to address two issues: (i) does the text imply a true zigzag function in which the value varies linearly with longitude or does the value stay constant for each zodiacal sign, increasing in stages from minimum in Cancer to maximum in Capricorn; and (ii) if the function is a true linear zigzag function, at which point in the zodiacal signs of Cancer and Capricorn do the values correspond? I have taken the value to relate to the beginning of each zodiacal sign, and assumed that the values are part of a true zigzag function. However, this is not certain and the figure should be regarded as illustrative only.

In most procedure texts for Jupiter the duration of invisibility is taken to be constant at either 29 or 30 *tithis* no matter where Jupiter is in the zodiac.[10] However, in reality there is a quite large variation of up to about 10 days in the duration of invisibility. This variation is dependent upon several factors: Jupiter's velocity, the sun's velocity, Jupiter's latitude and the inclination of the ecliptic to the horizon. However, all of these factors are approximately linked: the sun's velocity and the inclination of the ecliptic to the horizon are both dependent upon the sun's longitude; as Jupiter's latitude is more or less zodiacally fixed (especially for the same point in its synodic cycle), the effect of latitude is more or less dependent upon Jupiter's longitude, as is Jupiter's velocity.

From Figure 3 it may be seen that the variation in duration of invisibility modelled by the zigzag function is only qualitatively correct. In particular, although the minimum duration of invisibility is not at all bad, the amplitude is much too small. However, Swerdlow [1998], pp. 153–155 has shown that when the maximum and minimum values 27 and 32 *tithis* are taken to apply to the whole of the fast and slow arcs they are a good

[8] See already Neugebauer [1955], p. 429.
[9] Data in this figure was taken from N. A. Roughton's database of computer generated planetary phenomena for the Late Babylonian period; see Roughton [2002], p. 370 for a description of the modern theories used in compiling the database.
[10] Neugebauer [1975], p. 405 and ACT No. 813.

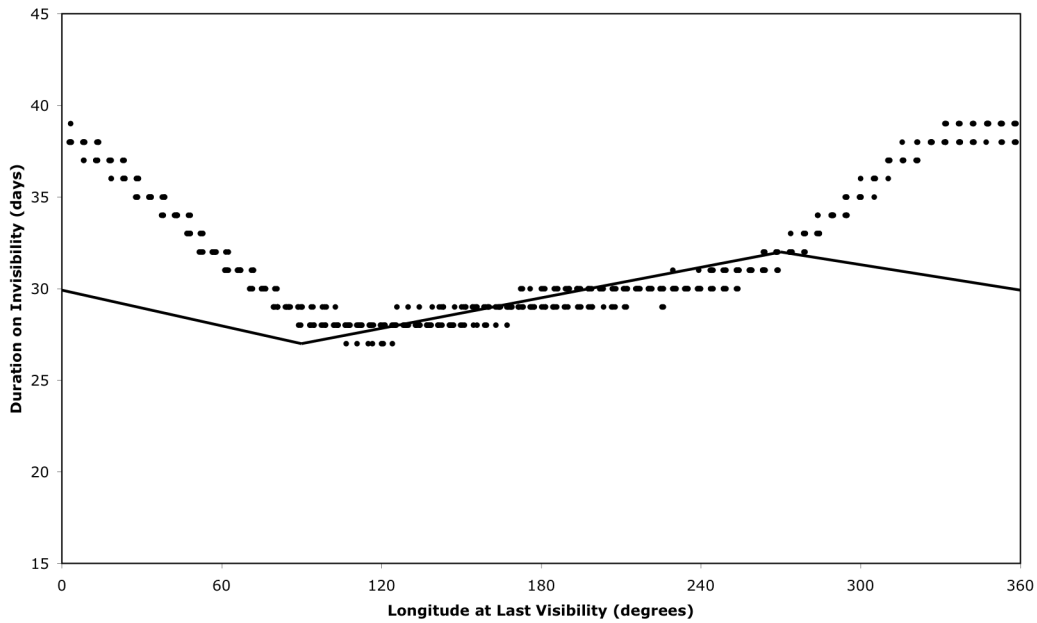

Figure 3. The duration of invisibility of Jupiter for the period –600 to 0.

approximation to the total variation in the total duration of the synodic time. It is possible that maximum and minimum values were taken across from such a scheme. The present model of the duration of invisibility, however, takes better account of the nature of the variation between maximum and minimum.

We can now return to the zigzag function in line 4'. This same zigzag function is written out zodiacal sign by zodiacal sign on ACT No. 813 Section 29 and ACT No. 817 Section 1. The beginning of ACT No. 813 Rev. III, 16 was read by Neugebauer [1955], p. 418: *šá* KA 2-*i* MÚL-BABBAR *ina* ALLA 6,10 DU ŠÚ "According to the second method, Jupiter moves (forward) in Cancer 6;10 (then) disappears (Ω)". Thus Neugebauer interpreted these numbers as a referring to arcs until last visibility.[11] However, given their link with the zigzag function in line 5' which refers to Jupiter's period of invisibility, I suspect that these numbers are also connected with the period of invisibility. It would be quite possible to read DU-*šú* instead of DU ŠÚ in ACT No. 813 and translate "According to the second method, Jupiter in Cancer 6;10 is its forward motion". Figure 4 shows the actual variation in the length of the synodic arc between last and first visibility of Jupiter along with the zigzag function from line 4'. A possible explanation for why the amplitude of variation is so minute is that the function was derived mathematically from the corresponding function for the duration of the synodic arc by dividing by 30 and the only empirical element was an observed minimum synodic arc.

[11] Neugebauer [1975], p. 452. Note here Neugebauer incorrectly described this function as being found on ACT No. 813 Section 4 and 814 Section 2 instead of ACT No. 813 Section 29 and ACT No. 817 Section 1.

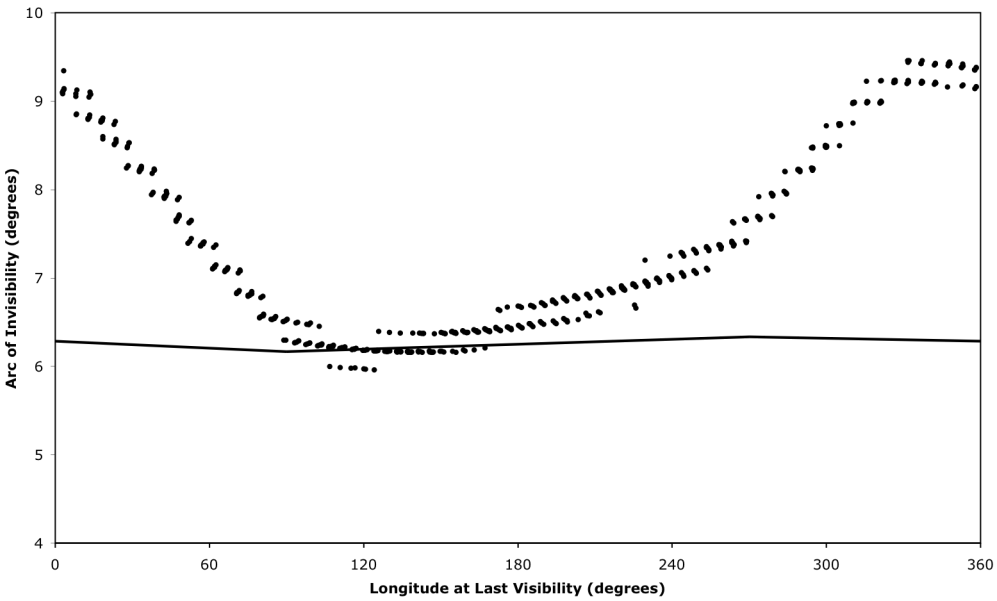

Figure 4. The length of the invisible stretch of the synodic arc of Jupiter for the period –600 to 0.

It is interesting to note that the zodiacal signs specified as maximum and minimum points of the schemes, Cancer and Capricorn, are the two zodiacal signs in which the latitude of Jupiter crosses from positive to negative latitude according to the rules of Atypical Text F.[12] This implies that the variation in the duration and arc of invisibility was linked conceptually primarily to Jupiter's latitude and not, for example, to its apsidal line (Pisces 12;30 to Virgo 12;30 in System A[13]). It may be significant, therefore, that this section follows a section which deals with Jupiter's latitude, although we should not read too much into sections being copied onto the same procedure text.

Section 3: Obv. 6'-7'

This section presents a velocity scheme for the subdivision of Jupiter's synodic arc. Line 6' gives a velocity of 0;10° per *tithi* for the first 30 *tithis* after first visibility (Γ to Γ′) and a velocity of 0;6,40° per *tithi* for the next 30 *tithis*.[14] These presumably refer to the slow arc, but a velocity of 0;10° is lower than expected. Line 7' gives a velocity of 0;3,20° per *tithi*, apparently for the first 30 *tithis* after Ψ; again, however, this is much lower than expected (perhaps the author is engaging in number play as 0;3,20 is half of 0;6,40).

[12] Steele [2003].
[13] Neugebauer [1975], p. 447.
[14] According to ACT No. 810 Jupiter's velocity is constant for 90 *tithis* between Γ′ and Φ.

Section 4: Obv. 8′–9′

This section gives the arcs and velocities for System A′′.

Section 5: Rev. 1′–2′

Too broken for comments.

Section 6: Rev. 3′–6′

I understand very little of this section. 11;3,20 is the value for the epact (difference between 12 months and the solar year) found in ACT No. 813 Sections 14–16, but I do not understand the remainder of this line. In line 5', 32° perhaps refers to an intermediate synodic arc in Libra and Taurus in the six zone scheme described in ACT No. 811 Section 1.

Section 7: Rev. 7′

Too broken for comments.

BM 40659 (= 81–4–28, 204)

Size: 4 × 5 cm.
Edges: No edges preserved.
Photograph: Figure 5.

Transliteration

1' […] 21,18 KI DU […]
2' […] *m*]*a-lak* [*šá* ...] *ina* ˹UŠ˺ IGI-*tú* ½ KÙŠ […]
3' […] RÍN 12 ˹ZI˺-*šú* 12,48 GÍR 13,[36 …]

4' […] ALLA 6,20 MÁŠ 1,40 TAB ŠÚ *ana* U[Š? …]
5' […] ˹x˺ *ina* MÁŠ 32 […]

6' […] x 30 ME 10 ZI-*šú* 30 […]
7' […] *ár-t*]*ú* 3 20 ZI-*šú* TA […]

8' […] EN 5,45 GÍR 30 [TAB …]

Figure 5. BM 40659. (Copyright The British Museum)

Critical Apparatus

2' ½ KÙŠ: Initially I read *šú-ú* here (Steele [2003], p. 280), following Neugebauer's reading of ACT No. 813 Obv. I, 16. The reading ½ KÙŠ was suggested by H. Hunger on seeing the photograph; see further below.

Translation and Commentary

This text is a duplicate of BM 36434 Obv. 1'–8'. For translation and commentary, see above.

BM 40661 (= 81–4–28, 206)

Size: 4 × 4 cm.
Edges: No edges preserved.
Photograph: Figure 6.

Figure 6. BM 40661. (Copyright The British Museum)

Transliteration

1' […] x GAR-GAR x […]
2' […] x 12,30 GAR-GAR […]
3' […] x x IGI TA IGI […]
4' [… 6 ME NI *šá*] ˹MU˺ *ina* 6,42 ME-M[EŠ …]
5' […] 40 *šá* KA 2-*i* A$^{?}$ TA 1$^{?}$ […]
6' [… 1]1,15 A-RÁ 1,8 12,4[5 …]
7' [… 17,4]5$^{?}$ KI DU-*ma* ŠÚ : *ina* 12 [MU-MEŠ 4,10 TAB …]
8' [… *ina* K]Á-*tú šá* 30 6,15 BE […]

9' [… TA 25 MAŠ-MAŠ EN 30 GÍR 36] ˹TAB TA 30 GÍR EN 25˺ [MAŠ-MAŠ 36 TAB…]

Translation

1' […] … add them … […]
2' […] … 12,30 add them […]
3' […] … first visibility. From first visibility […]
4' [… 6 days duration of] ˹the year˺. In 6,42 days […]
5' […] 40. According to the second method, … from … […]

6' [… 1]1,15 multiplied by 1,8 equals 12,4[5 …]
7' […17;4]5[?] degrees of longitude it moves forward and (reaches) last visibility. In 12 [years add 4,10 (degrees) …]
8' […] … concerning 30 (days), 6,15 if appearing[?] […]

9' […From 25 Gemini to 30 Scorpio] add [36.] From 30 Scorpio to 25 [Gemini add 36. …]

Critical Apparatus

4' Restored from ACT No. 813, Obv. I, 3 and BM 36680 Obv. 11'.
7' Restored from ACT No. 813, Obv. I, 5 and BM 36680 Obv. 12'.
9' Restored from ACT No. 813, Obv. I, 8.

Commentary

Section 1: Obv. 1'–8'

This section is related to BM 36680 Section 1, ACT No. 813 Section 1 and ACT No. 814 Section 1. In line 4', 6,42 days is an alternative or more likely truncated version of 6,42;5,10 *tithis* for the synodic time on the slow arc of System A, A′, etc. I do not understand the significance of the multiplication in line 6', although it is mathematically correct. M. Ossendrijver suggests that 11,15 might be the progress in longitude in 3 months between Γ′ and Φ and 1,8 the ratio of two arcs; this ratio would fit the slow and greater of the two intermediate arcs of the six zone described in ACT No. 811 Section 1 (30° and 34° respectively). In line 7', 17;45° is known as the interval between Ψ and Ω on the slow arc of System A, A′, etc.

Section 2: Obv. 9'

This section gives the standard synodic arcs for System A.

Procedure Texts Concerning the Latitude of Jupiter

BM 36680, BM 36434, BM 40659 and ACT Nos. 813 and 814 contain copies of what must have been a standard section concerning the latitude of Jupiter. Since my earlier investigation of this section,[15] I have identified BM 36434 and collated all of the sources. Collation of ACT No. 813 revealed that there are approximately 10 signs missing at the beginning of line 16, and about 15 signs missing at the beginning of line 17. This implies

[15] Steele [2003], pp. 278–282.

that the preserved signs read by Neugebauer [*š*]*ú-ú i-šáp-pil* do not correspond in placement to his *šú-ú* SIG in ACT No. 814. Instead we must have two sentences which include the phrase "it is low". More importantly, however, the realization, based upon a suggestion by H. Hunger, that the signs *šú-ú* should be read ½ KÙŠ changes the interpretation of this section from a qualitative description of Jupiter's latitude, to a quantitative scheme. The signs BAR (= ½) and ŠÚ are very similar, comprising two wedges: one vertical wedge and a second wedge crossing the vertical wedge horizontally in the case of BAR () and at a 45 degree angle to the bottom right in ŠÚ (). Comparison of the sign in question in line 2' of BM 40659 with clearly defined (by context) ŠÚs in lines 6' and 7' shows that the sign has a much higher and horizontal wedge. Inspection of the corresponding signs in the photographs of the other sources shows that in all cases the sign can very plausibly be read BAR (= ½). Indeed, it is worth noting that in copying the relevant fragment of ACT No. 813 as LBAT No. 147, T. G. Pinches copied a BAR, not a ŠÚ. KÙŠ and *ú* are the same sign. The reading ½ KÙŠ here is further suggested by the unpublished procedure text BM 82824 made known to me by M. Ossendrijver which in line 10' reads: [... *t*]*u*$_4$ ½ KÙŠ *al-la* MURUB$_4$ NIM *ina* UŠ [...] "... ½ cubit above the middle it is high; at the [...] station [...]". The addition of the phrase *al-la* MURUB$_4$ "above the middle (of its band of latitude)" implies that we must read here the distance ½ KÙŠ, not *šú-ú*.

An improved composite text, taking into account the spacing, is given below.

BM 36680, 17': *ina* DAGAL *ma-l*[*ak* …]
BM 36434, 2': […] *ma-lak šá ... ina* ˹UŠ x˺ [...]
BM 40659, 2': […*m*]*a-lak* [*šá* ...] *ina* ˹UŠ˺ IGI-*tú* ½ KÙŠ […]
ACT 813, 16: […] ˹UŠ˺ IGI-*tu*$_4$ ½ KÙŠ
ACT 814, 9: [...] *ina* UŠ IGI-*tu*$_4$ ½ KÙŠ *šá-qa ina*
ina* DAGAL *ma-lak šá ... ina* UŠ IGI-*tu*$_4$ ½ KÙŠ *šá-qa ina
in the width of the path .... At first station ½ cubit it is high. At

BM 36680, 18': […] ½ KÙŠ *i-šáp-pil* […]
ACT 813, 17: […] ½ KÙŠ *i-šáp-pil* […]
ACT 814, 9: *ár-tu*$_4$ ½ KÙŠ SIG MÚL-BA[BBAR
***ár-tu*$_4$ ½ KÙŠ SIG MÚL-BA[BBAR .....] ½ KÙŠ *i-šáp-pil* […]**
second (station) ½ cubit it is low. Jup[iter .....] ½ cubit it is low […]

Unfortunately, the text remains far from complete and several problems remain in its interpretation. The section apparently begins with a statement that indicates that we are concerned with the movement of Jupiter within its band of latitudinal motion, called here "the width of the path" (DAGAL *ma-lak*). This expression is known from texts which deal with the moon's latitude and refers to the band between the extremes of a heavenly body's motion 'up' and 'down' as it moves forward or backward through the zodiac. For

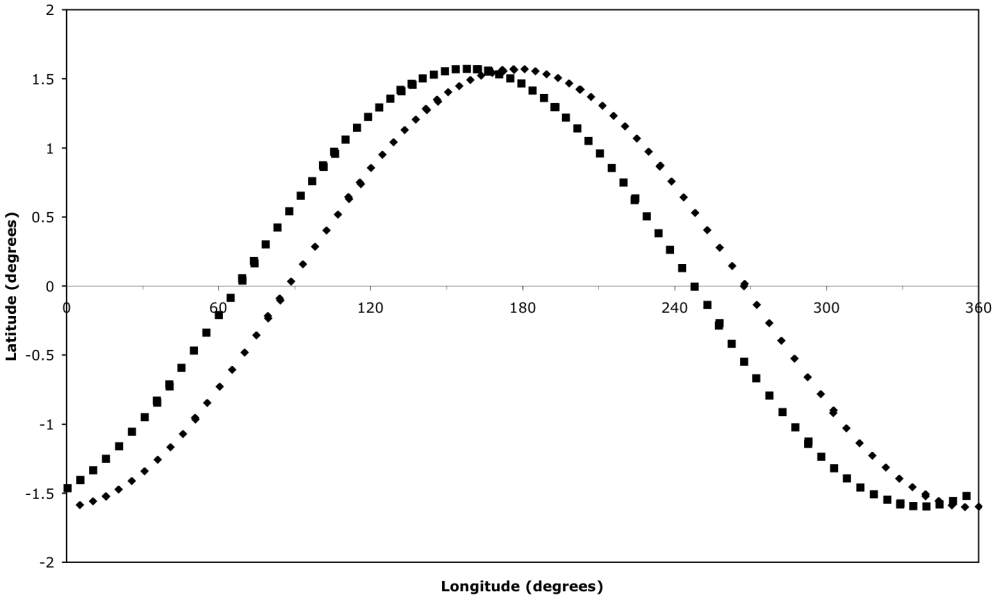

Figure 7. Latitude and longitude of first (diamond) and second (square) stations of Jupiter from –300 to –200.

example, in ACT No. 200 Obv. I, 20 we read DÙ *šá* NIM *u* SIG *šá sin* ÁB *ana* ÁB 12 DAGAL *ma-lak* ^{d}*sin* "Procedure for the going up and going down of the moon, month by month. 12 (degrees is) the width of the path of the moon" and in Atypical Text E Obv. 15 we find *ina* 9 MU-MEŠ 6 KÙŠ DAGAL *ma-la-ka ul-tu* NIM *ana* BÙR BÙR-*ma* "In 9 years it goes down 6 cubits, the width of the path, from being high to being low".

Following the introductory words we appear to have two more or less parallel statements. The first statement is fully preserved and says that at its first station Jupiter is ½ cubit high in latitude and at the second it is ½ cubit low. Of the second statement, only the final words "½ cubit it is low" remain. Astronomically it is only the case that first station is at higher latitude than second station in half the zodiac (from about Libra to Pisces); in the other half of the zodiac (from about Aries to Virgo) the situation is reversed and second station is at higher latitude than first station (see Figure 7).[16] Thus the second statement is presumably the complement of the first, which said that at the second station it is ½ cubit high and at the first ½ cubit low.

In Table 2 I list the latitude and longitude of successive first and second stations of Jupiter for the twenty years starting in –300 (= SE 11).[17] Depending upon which part of the zodiac Jupiter is located in, the latitude of the planet changes by up to ±0.29° between

[16] Data in this figure was taken from Roughton's database.
[17] Data again taken from Roughton's database.

	Φ			Ψ		Φ → Ψ	
Date	Long (°)	Lat (°)	Date	Long (°)	Lat (°)	Δ_{Long} (°)	Δ_{Lat} (°)
–300 Oct 11	79.3	–0.22	–299 Feb 7	69.3	+0.06	–10.0	+0.28
–299 Nov 11	111.2	+0.65	–298 Apr 12	101.2	+0.88	–10.0	+0.23
–298 Dec 11	141.8	+1.28	–297 Apr 12	131.8	+1.42	–10.0	+0.14
–296 Jan 11	171.9	+1.57	–296 May 13	162.0	+1.57	–9.9	0.00
–295 Feb 11	202.4	+1.42	–295 Jun 13	192.5	+1.29	–9.9	–0.13
–294 Mar 16	234.0	+0.87	–294 Jul 7	224.2	+0.62	–9.8	–0.25
–293 Apr 20	267.3	+0.00	–293 Aug 18	257.5	–0.29	–9.8	–0.29
–292 May 26	302.5	–0.91	–292 Sep 22	292.7	–1.14	–9.8	–0.23
–291 Jul 3	339.0	–1.52	–291 Oct 29	329.0	–1.58	–10.0	–0.06
–290 Aug 9	15.4	–1.52	–290 Dec 4	5.4	–1.40	–10.0	+0.12
–289 Sep 13	50.6	–0.95	–288 Jan 9	40.6	–0.71	–10.0	+0.24
–288 Oct 15	84.0	–0.09	–287 Feb 11	73.9	+0.18	–10.1	+0.27
–287 Nov 15	115.6	+0.75	–286 Mar 16	105.6	+0.97	–10.0	+0.22
–286 Dec 16	146.2	+1.35	–285 Apr 17	136.2	+1.47	–10.0	+0.12
–284 Jan 15	176.3	+1.57	–284 May 17	166.4	+1.56	–9.9	–0.01
–283 Feb 15	206.9	+1.37	–283 Jun 18	197.1	+1.22	–9.8	–0.15
–282 Mar 20	238.8	+0.76	–282 Jul 20	228.9	+0.50	–9.9	–0.26
–281 Apr 25	272.4	–0.13	–281 Aug 23	262.5	–0.42	–9.9	–0.07

Table 2. The latitude and longitude of successive first (Φ) and second (Ψ) stations of Jupiter from –300 to –281.

first and second station. This change in latitude is much smaller than the ½ cubit (= 1°)[18] mentioped in the text. It therefore seems that the text is not describing the variation in latitude between one first station the following second station a few months later. Probably, the text is instead referring to the difference in latitude between Jupiter at first and second station when the planet is at the same longitude. Since Jupiter does not have the Earth at the centre of its orbit its latitude is dependent both upon the planet's position in the ecliptic and its elongation from the sun. As a result Jupiter's latitude falls into a snaking band of a little less than 1° in width that is, neglecting precession etc., zodiacally fixed.[19] From Figure 7 we can see that for the same longitude first station can be up to about 0.7° higher or lower in latitude than the second station; the 1 cubit value given in the text is somewhat bigger than this,[20] but perhaps not unreasonably so.[21] The zodiacally

[18] In theoretical astronomical texts a cubit was always taken to be equivalent to 2°; see Steele [2003], pp. 283–286. Observationally, the cubit seems to have been slightly larger than this; see Jones [2004].
[19] See Steele [2003], pp. 271–272 and in particular fig. 2.
[20] The text talks about being ½ cubit high and ½ cubit low so perhaps the total variation should be 1 cubit. Since 1 cubit is much too high, I interpret the text as meaning high and low within the ½ cubit variation.
[21] Cf. the estimate of the lunar diameter as 1° in Atypical Text E and elsewhere. In that case, however, an incorrect lunar diameter is only used as a generating number which gives accurate final results.

fixed latitude scheme described in Atypical Text F does not distinguish between the different stages of Jupiter's synodic cycle. I think it very likely that the rule described in the present texts is used as a supplement to that rule, or one similar to it. Support for this view comes from BM 82824 where the sentence related to the present section comes straight after a copy of the Atypical Text F latitude scheme.

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