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New Fragments of Babylonian Astronomical Procedure Texts

Mathieu Ossendrijver

Institute for History of Knowledge in the Ancient World
Freie Universität Berlin

Abstract

This paper presents nine previously unpublished fragments of Babylonian procedure texts from the corpus of mathematical astronomy. Texts A and B contain planetary procedures that complement our knowledge of the Babylonian methods for Mercury (systems A_1, A_2), in particular those concerning daily motion, and Saturn (systems B, B″). The remaining seven fragments (Texts C–H) are concerned with the Moon. Text C contains procedures based on a previously unknown variant of system A. Texts D–G belong to lunar system A. Text H comprises two new fragments of a procedure text for lunar system K. Texts E–H are joins to previously published tablets.

Introduction

The editions presented here constitute an update to the published corpus of about 102 Babylonian astronomical procedure texts (*BMAPT*). These texts in the Late Babylonian dialect of Akkadian contain rules, usually formulated as instructions, for computing lunar, solar, and planetary phenomena, in particular their dates and zodiacal positions. Many procedure texts also include non-instructional statements about periods and other characteristic parameters underlying the computational models. Together with about 330 computed tables of lunar, solar, or planetary data, the procedure texts constitute the corpus of Babylonian mathematical astronomy.[1] The computational methods were created in the wake of the introduction of the uniform zodiac in the second half of the fifth century BCE.[2] All computations are based on sexagesimal place value notation.

The procedure texts presented here include instructions addressing the reader in the second person, as well as statements about planetary motion formulated in the third person. The instructions either employ an example-based formulation or a general formulation. In the former case computations are exemplified with concrete

[1] For editions of the the lunar tables see Neugebauer (1955), for the planetary tables see Ossendrijver (2025).

[2] For an introduction to the Babylonian mathematical astronomy and an overview of its methods see *BMAPT*.

numerical values, in the latter case the quantities to be computed do not assume a numerical value. The tablets originate from Uruk (Text A) and, most likely, Babylon (B–H), the only two Babylonian sites where tablets with mathematical astronomy have come to light. Most of them cannot be precisely dated, because they lack a date of writing and the computations do not involve any datable phenomena.

The conventions and notations used in this paper are essentially the same as in *BMAPT*. O/R indicates that the tablet is turned over from obverse to reverse along the horizontal axis, O–R that it is turned over along the vertical axis. The size of a fragment is reported in the form width × height × thickness. A measure followed by an asterisk (*) indicates that the tablet is incompletely preserved in that direction. Where possible the asterisk is replaced by an estimate of the original size. Numbers in floating sexagesimal place value notation are transliterated with all digits separated by periods. In translations they are represented in the conventional absolute notation where possible, with all digits separated by commas, except between the digit pertaining to 1 and the next one pertaining to 1/60, where the semicolon (;) is used as a separator. Longitudinal displacements are expressed in UŠ, corresponding to the modern degree of arc, but this unit was usually omitted by the Babylonian scribes. In the commentaries, astronomical quantities are represented by the following conventional modern symbols (see also *BMAPT*):

B ecliptical longitude [zodiacal sign and number of UŠ within it]
T date [year, month, day or mean tithi ($\bar{\tau}$)]
v longitudinal displacement per day [UŠ/day]
dv daily difference of v [UŠ/day]
δB longitudinal displacement [UŠ]
δT time interval [days or mean tithis ($\bar{\tau}$)]
σ synodic arc = longitudinal displacement between successive instances of the same synodic phenomenon [UŠ]
τ synodic time = time interval between successive instances of the same synodic phenomenon [$\bar{\tau}$]
$\delta\Sigma$ longitudinal displacement between two different synodic phenomena [UŠ]
$\delta\tau$ time interval between two different synodic phenomena [$\bar{\tau}$]

I Text A (A 3460): Mercury system A_1

museum number	A 3460
provenience	Uruk
date	ca. 230–170 BCE
measures	6.1(*) × 5.2(*) × ca. 2 cm
arrangement	O/R
cuneiform text	Fig. 1
content	Mercury system A_1: subdivision of synodic cycle

Transliteration

Obverse

(*n* lines missing)

1′ [xx] ⸢xxx⸣ [...]

2′ *ina* šu$_2$ ⸢*lu*⸣ *ina* ⸢uš⸣ [xxx] *ina* ⸢TE *lu*⸣-*maš* ŠU$_2$ [...]

3′ ^{d}gu$_4$.ud *ina* kur *ina* ⸢ḫun igi⸣-*ma* 14 u$_4$.meš ⸢du⸣ [...]

4′ *mi-šil ša$_2$* u$_4$.meš-*šu$_2$ ša$_2$* me 18.30 ⸢zi⸣ [...]

5′ *ina* kur *ina* mul$_2$.mul$_2$ igi-*ma* 1⸢6$^?$⸣ u$_4$.meš ⸢du$^?$⸣ [...]

6′ *mi-šil ša$_2$* u$_4$.meš-*šu$_2$ ša$_2$* me ⸢10 x$^?$ zi UR$^?$⸣ [...]

7′ *ina* kur *ina* ⸢maš.maš⸣ igi-*ma* 19 [u$_4$.meš du ...]

8′ [...]

Reverse

1 ⸢*ina* kur⸣ [*ina* alla igi-*ma* ...]

2 *mi-šil ša$_2$* ⸢u$_4$⸣.[meš-*šu$_2$* ...]

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3 ⸢*ina* kur⸣ *ina* a igi-*ma* ⸢27⸣ u$_4$.meš du-⸢*ak*⸣ [...]

4 *mi-šil ša$_2$* u$_4$.meš-*šu$_2$ ša$_2$* me ⸢5⸣.30 ⸢zi⸣ [...]

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5 *ina* kur *ina* absin igi-*ma* ⸢30 u$_4$.meš⸣ [du ...]

6 ⸢*mi-šil*⸣ *ša$_2$* u$_4$.meš-⸢*šu$_2$*⸣ [*ša$_2$* me ...]

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7 ⸢*ina*⸣ [kur *ina*] ⸢rin$_2$⸣ [igi-*ma* xxx ...]

8 [xxxxxxxx ...]

(ca. *n* lines missing)

Translation

Obverse

(ca. *n* lines missing)

P1′ 1′ [...] ⸢...⸣ [...]

2′ At the setting ⸢or⸣ at the ⸢station⸣ [...] or at the approaching(?) of a zodiacal sign ... [...]

P2′ 3′ Mercury appears in the East in Aries, then 14 “days” it ⸢proceeds⸣ [...]

4′ Half of its “days” per “day” (0);18,30 ⸢it moves (or: the displacement)⸣ [...]

P3′ 5′ It appears in the East in Taurus, then 1⸢6$^{?}$⸣ “days” it ⸢proceeds⸣ [...]

6′ Half of its “days” per “day” (0);⸢10... it moves (or: the displacement)⸣ ... [...]

P4′ 7′ It appears in the East in ⸢Gemini⸣, then 19 [“days” it proceeds ...]

8′ [...]

Reverse

P5′ 1 [It appears] ⸢in the East⸣ [in Cancer, then ...]

2 Half of its “days” [per “day” ...]

P6′ 3 It appears in the East in Leo, then 27 “days” it proceeds ... [...]

4 Half of its “days” per “day” (0);⸢5⸣,30⸢...⸣ [...]

P7′ 5 It appears in the East in Virgo, then ⸢30 “days”⸣ [it proceeds ...]

6 Half of its “days” [per “day” ...]

P8′ 7 [It appears] ⸢in⸣ [the East in] Libra, [then ...]

8 [...]

(ca. *n* lines missing)

Philological remarks

O1′ ⸢xxx⸣: traces of about three signs, the second of which could be BAR.

O2′ ⸢uš$^{?}$⸣: the beginning of a sign similar to NI or uš, in which case it could represent “station.” TE: either a form of *ṭeḫû*(te), “to approach,” or the determinative mul$_2$ connected to the following *lu-maš*. The intended meaning of the following ŠU$_2$ is unclear (possessive suffix -*šu$_2$* or šu$_2$ = *irabbi*, “it sets”?).

O3′ ^{d}gu$_4$.ud = *Šiḫṭu* = Mercury. du (see also R3): most probably to be read *illak*, “it proceeds,” in the sense of forward motion along the ecliptic.

O4′ ⸢zi⸣ (also O6′, R4): either to be read *inassaḫ* (3rd p. sg. pres. G of *nasāḫu*), “it moves,” or *nisḫu*, “displacement” (see commentary).

O5′ 1⸢6$^{?}$⸣: a reading 17 or 18 is possible but less likely.

O6′ ⌜x: traces of a vertical wedge belonging to a numeral 1–8 or to the following sign zi. ⌜UR?⌝: meaning unclear, perhaps *taš* = *tašpiltu*, "difference"? A reading LU is also possible.

R3 ⌜*ak*⌝: the beginning of a sign, most likely *ak*, which results in du-*ak* = *illak*, "it proceeds," and rules out the alternative possibility DU = *izzaz*(gub), literally "it stands (in the sky)."

R7 ⌜rin$_2$⌝: faint traces compatible with the expected rin$_2$ = Libra.

Commentary

This fragment preserves the lower left half of the obverse and the upper left half of the reverse of a tablet, including portions of the original left and lower (upper) edges.[3] It belongs to a group of tablets that were excavated unscientifically in Uruk and acquired by the Institute for the Study of Ancient Cultures (Chicago), formerly known as Oriental Institute, by James Henry Breasted in 1919/20 (Proust and Steele 2019, 41). A comparison with other tablets from Uruk reveals that it was almost certainly written by priestly scholars connected to the Rēš, sanctuary of the skygod Anu and his spouse Antu, in the period 230–170 BCE. The fragment partly preserves eight procedures (P1′–P8′) about the subdivision of the synodic cycle of an unidentified planet (P1′) and Mercury (P2′–P8′). They are separated by single horizontal rulings. P2′–P8′ are the only known procedures concerned with the daily motion of Mercury.

P1': a planet

The preserved part of P1′ does not allow a satisfying interpretation, in part because no parallels have been identified. The term "setting" can denote the morning last or evening last of Mercury or Venus, or the last appearance of Mars, Jupiter, or Saturn. The term "station" can denote the station of any planet. Mercury is likely because of the following procedures.

P2'–P8': Mercury system A_1, morning first to morning last

P2′–P8′ form a sequence of similar statements about Mercury's longitudinal motion between the synodic phenomena morning first and morning last, each of which covers one of the zodiacal signs from Aries (P2′) until Libra (P8′). They were almost certainly followed by five analogous ones for Scorpio through Pisces. P2′ is distinct in that it starts with the name of the planet. The template underlying P2′–P8′ can be partly reconstructed as follows:

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[3] The thickness of the tablet was not measured but is estimated to be about 2 cm (± 0.5 cm).

ina kur *ina* Z igi-*ma* δT u_4.meš du-*ak* [...]
It appears in the East in (zodiacal sign) Z, then δT “days” it proceeds [...]

mi-šil ša₂ u_4.meš-*šu₂ ša₂* me x zi UR$^?$ [...]
Half of its “days” per “day” x the displacement ... [...].

Time intervals are expressed in “days” (*ūmu*), which denote mean tithis, a unit corresponding to 1/30 of the mean synodic month (≈ 29;31,50,8,20/30 days). The symbols δT and x replace concrete numbers on the tablet (P2′: $\delta T = 14$ “days,” $x = 18.30$; P3′: $\delta T = 16^?$ “days”, x between 10 and 18; P6′: $\delta T = 27$ “days,” $x = 5.30$).[4] No exact parallel for the template is attested.[5] After the “appearance in the East,” corresponding to morning first (MF), the planet is said to proceed for δT “days.” The endpoint is broken off and can only be the morning last (ML). This follows from a comparison with values of the time from morning first to morning last, $\delta\tau$(MF to ML), known from system A_1 (Table 1).[6] In system A_1 Mercury’s morning last is treated as a satellite of morning first, i.e. its longitudes (B) and dates (T) are computed from those of the immediately preceding morning first in accordance with

$$B(\text{ML}) = B(\text{MF}) + \delta\Sigma(\text{MF to ML}), \tag{1}$$

$$T(\text{ML}) = T(\text{MF}) + \delta\tau(\text{MF to ML}), \tag{2}$$

where $\delta\Sigma$(MF to ML) is the longitudinal distance from morning first to morning last. The algorithms for morning first do not concern us here. The values of $\delta\Sigma$(MF to ML) and $\delta\tau$(MF to ML) that have been reconstructed from synodic tables derive from control values $\delta\tau_k$(MF to ML) anchored at 15 UŠ of the zodiacal signs (Table 1). The intervals mentioned in P2′–P8′ (O3′, O5′, O7′, R3, R5) coincide with the $\delta\tau_k$(MF to ML) in Table 1, which implies that P2′–P8′ are connected to this well-known scheme.

The expression “its days” in the second part of the template most likely denotes the interval $\delta\tau$(MF to ML). The expression “per day x it moves (or: the displacement) [...]” refers to daily motion along the ecliptic.[7] But what is quantified by x? Modern computations of Mercury’s daily longitudinal motion indicate that v changes from a small value near MF, which is retrograde (negative) for a number of days except if Mercury is near Aries, to a maximum of ca. 2 degrees/day near ML, with an average of about +1 degree/d. Even though Mercury usually moves in the retrograde direction near MF, the total displacement $\delta\Sigma$(MF to ML) is always prograde (positive). One expects the model for v to result in values of $\delta\Sigma$(MF to ML)

[4] For the concept of “template procedures” see *BMAPT*, 37–38.

[5] For a related template see, for instance, *BMAPT*, 66.

[6] For the complete interpolation scheme see *BMAPT*, 70: Table 3.8.

[7] For another example of the expression “half its days” see Ossendrijver (2024).

k	B_k	$\delta\tau_k$(MF to ML) [$\bar{\tau}$]	$\delta\Sigma_k$(MF to ML) [UŠ]
1	15 Aries	14	12
2	15 Taurus	16	14
3	15 Gemini	19	18
4	15 Cancer	24 or 25	22
5	15 Leo	27	26
6	15 Virgo	30	30
7	15 Libra	36	34

Table 1: Time intervals $\delta\tau_k$(MF to ML) [$\bar{\tau}$] and corresponding distances $\delta\Sigma_k$(MF to ML) [UŠ] for Aries through Libra according to Mercury system A_1.

roughly similar to the $\delta\Sigma_k$(MF to ML) in Table 1. The mean value of v should therefore not differ too much from $\delta\Sigma_k$(MF to ML)$/\delta\tau_k$(MF to ML). Inserting the values from Table 1 yields ratios in the range 0;51 ... 1 UŠ/d. Since the values of x are (far) outside this range, they cannot represent mean values of v for the interval from MF to ML.

days	interval [d]	v_{begin} [UŠ/d]	v_{end} [UŠ/d]	dv [UŠ/d^2]	δB [UŠ]
1	1	–0;18			–0;18
2–4	3	0;17	0;15	–0;1	0;48
5–11	7	0;15	unknown	unknown	1;38,15
12–24	13	0;27,15	1;36,15	0;5,45	13;32,45
25–32	8	1;37,30	1;37,30	0	13
total	32				28;41

Table 2: Mercury's motion from MF (day 1) to ML (day 32) as modeled in the daily motion table A 3425.

The numbers for x can also be compared with the scheme for Mercury's motion from MF to ML attested in A 3425, a table with daily positions for year 122 of the Seleucid Era (190–189 BCE).[8] The author of A 3460 may well have known that scheme, because both tablets originate from the same circle of scholars connected to the Rēš temple in Uruk. In A 3425 Mercury proceeds from morning first at 29;30 Virgo to morning last at 28;11 Libra, corresponding to a distance $\delta\Sigma$(MF to ML) = 28;41 UŠ, in 32 days (Table 2). This time interval equals the mean value of $\delta\tau_k$(MF to ML) for Libra and Virgo (Table 1), consistent with having been computed through linear interpolation with respect to B(MF) = 29;30 Virgo, a position

[8] The relevant zodiacal positions are contained in A 3425 O.iii′.25–R.i.27. For a new edition of this tablet see Ossendrijver (2025); for previous editions and studies see *ACT* No. 310 and Huber (1957), 276–277.

almost exactly halfway between 15 Virgo and 15 Libra. But in other respects A 3425 deviates from Table 1, because 28;41 UŠ is not halfway between the values of $\delta\Sigma_k$(MF to ML) for Virgo and Libra, but halfway between those for Leo and Virgo.[9] It follows that the scheme for v underlying A 3460 cannot be expected to exactly reproduce the values of $\delta\Sigma_k$(MF to ML) from Table 1.

In A 3425 v varies rather irregularly until day 11 after the morning first, setting out from a retrograde value as expected (Table 2). From day 12 v increases daily by 0;5,45 UŠ/d until v = 1;37,30 UŠ/d on day 25, after which v remains constant. Could the numbers for x represent constant values of v that apply in the first half of the interval from MF to ML, which would amount to a simpler model than the one underlying A 3425? On that assumption they must be interpreted as 0;18,30 (O4′), 0;10 ... 0;18 (O6′), and 0;5,30 (R4), and zi = *inassaḫ*, "it moves." The resulting longitudinal distances covered during the first half of the interval then equal $x\delta\tau/2 \approx$ 1–2 UŠ. However, in order to obtain total distances $\delta\Sigma$(MF to ML) in the expected range 15–30 UŠ (Table 1), implausibly large values of v must have applied in the second half of the interval.

	$\delta\tau/2$ [d]	x [UŠ/d^2]	$\delta\Sigma$(MF to ML) = $(3/8)x(\delta\tau)^2$ [UŠ]
P2′	7	0;18,30	22;39,45
P3′	8	0;10 ... 0;18	16 ... 28;48
P6′	13;30	0;5,30	25;3,33,45

Table 3: Parameters of Mercury's motion from MF to ML according to P2′, P3′, and P6′ if x is interpreted as dv, the daily increment of v.

It therefore seems more likely that P2′–P7′ prescribe linearly increasing values of v, analogous to Mercury's motion in days 12–24 after MF in A 3425. On that assumption the numbers for x do not represent v but its daily increment dv. The signs zi and UR that follow it in O4′ (P2′) and O6′ (P3′) could express the relationship between dv and v. Indeed zi can represent *nisḫu* = "displacement," the usual term for v, and UR (O6′) can be read as *taš*, a common abbreviation of *tašpiltu*, "difference" (dv). The syntax of x zi UR [...] is not fully clear, but this need not invalidate the interpretation $x = dv$. On that assumption $x\delta\tau/2$ is the total increase of v during the first half of the interval and $(1/8)x(\delta\tau)^2$ is the corresponding longitudinal distance (setting $v = 0$ at morning first as a rough approximation). If v remains constant in the second half of the interval, as in A 3425 during days 25–32 after the morning first, then the distance traveled in the second half is $x(\delta\tau)^2/4$, so

[9] In synodic tables, two different usages of the control values $\delta\Sigma_k$(MF to ML) and $\delta\tau_k$(MF to ML) are attested. In the simplest approach the values for the zodiacal sign of MF were used without modification. Alternatively linear interpolation was applied between adjacent values based on the exact longitude of MF.

that $\delta\Sigma$(MF to ML) $= (3/8)x(\delta\tau)^2$. The values obtained by inserting x and $\delta\tau$ are roughly in the expected range (Table 3), which speaks in favor of the interpretation of x as the daily increment of v.

II Text B (BM 36950): Mercury system A_2

museum number	BM 36950 (80–6–17, 691)
provenience	Babylon
date	ca. 350–50 BCE
measures	4.5(*) × 7.2(*) × 2.0(*) cm
cuneiform text	Fig. 2
content	Mercury system A_2: subdivision of synodic cycle

Transliteration

Side X

	i	ii	iii
	(unknown number of lines missing)		
1′	[xxxxx]	⌜52 ta⌝ [xx	...]
2′	[xxxx] ⌜x⌝	en 1⌜2⌝ [xxx	...]
3′	[xx] ⌜nim⌝ igi	ta 1⌜2⌝ [x	...]
4′	⌜1⌝4 gir₂ 12 pa maš₂	en 20 pa 1.10⌜x⌝	...]
5′	12 gu 18 *zib*	ta 20 pa	⌜ta⌝ [...]
6′	⌜15 x⌝ ḫun	en 10 maš	⌜1.x⌝ [...]
7′	[3]⌜7?⌝ 35 mul₂	58.30	ta [...]
8′	[xx] ⌜maš 2⌝2 alla		2.1⌜5?⌝ [...]
9′	[xx] ⌜x⌝ gaba.ri mu.an.na 6 ⌜x⌝[...]		
10′	[xx] ⌜x⌝ ta *u₄-mu* igi en ⌜10x⌝ [...]		
11′	[xx] ⌜x⌝ a.ra₂ 20 ⌜du⌝ [...]		
12′	[xx] ⌜x 30 x xx⌝ [...]		
	(unknown number of lines missing)		

Translation

Side X

	i (P1′)	ii (P2′)	iii (P3′)
	(unknown number of lines missing)		
1′	[...]	⌜52. From⌝ [...	...]

	2′	[...] ⸢...⸣	until 1⸢2⸣ [...	...]
	3′	[...] ⸢the East⸣ it appears,	From 1⸢2⸣ [...	...]
	4′	⸢1⸣4 Sco, 12 Sgr Cap,	until 20 Sgr 1,10⸢...⸣.	...]
	5′	12 Aqr, 18 Psc	From 20 Sgr	⸢From⸣ [...]
	6′	⸢15 ...⸣ Ari	until 10 Gem	⸢1.x⸣ [...]
	7′	[3]⸢7?⸣, 35 Tau	58;30.	From [...]
	8′	[...] ⸢Gem, 2⸣2 Cnc.		2,1⸢5?⸣ [...]
P4′	9′	[...] ⸢...⸣, equivalent of the year, 6 ...[...]		
P5′	10′	[...] ⸢...⸣ from the day of appearance until ⸢10+x⸣ [...]		
	11′	[...] ⸢... you multiply⸣ times 20 [...]		
	12′	[...] ⸢... 30 ...⸣ [...]		
		(unknown number of lines missing)		

Philological remarks

X.i.2′ ⸢x⸣: remains of a sign compatible with ME, perhaps representing "day."

X.i.3′ ⸢nim⸣ igi: perhaps part of *ina* nim igi, "it appears in the East" (morning first).

X.i.5′ *zib* = Pisces: written over a sign with three vertical wedges which remain visible below *zib*.

X.i.6′ ⸢15 x⸣: a damaged or partly erased sign, perhaps BAR, of unknown meaning.

X.i.7′ ⸢7?⸣: a reading 8 is also possible.

X.i.8′ xx: the missing number before maš is expected to be similar to 22.

X.ii.4′ ⸢x⸣: a numeral 4...8.

X.iii.8′ x: a numeral 5...8.

X.i.9′ gaba.ri is preceded by remains of a vertical wedge. 6 is followed by a sign beginning with two small *Winkelhaken* signs as in UD.

X.i.10′ ta is preceded by traces of a sign similar to NI. en is followed by a numeral 10–30.

X.i.11′ ⸢x⸣: a sign ending in three horizontal wedges.

X.i.12′ The 30 is preceded by the contours of a numeral 1–8 and followed by traces of a sign similar to DU and several numerals.

Commentary

This fragment is inscribed on one side (X); the other side is destroyed. According to the museum registers it originates from Babylon (Leichty, Finkel and Walker 2019, 316). It may belong to the same tablet as BM 36436 (*BMAPT* No. 2), but they do not directly join.

P1′: Mercury system A_2, time from evening last to morning first

The numbers and zodiacal signs in X.i.4′–5′ are very similar to the interpolation scheme for $\delta\tau$(EL to MF) connected to system A_2 (*BMAPT*, 72: Table 3.11) that underlies the dates of Mercury's MF in the synodic table BM 36723+ (*ACT* No. 300a).[10] At first sight X.i.6′–8′ appear to deviate from this scheme, because Aries (X.i.6′) is preceded by 15, inconsistent with the expected value of about $38^{\overline{\tau}}$. However, a 37 or 38 can be restored in X.i.7′ and the 15 can be interpreted as the position within Aries where it applies (Table 4). The 15 probably applies in all zodiacal signs (Ossendrijver 2025). Since it is written only for Aries, it appears that the procedure was copied from a version that began in Aries. The expression nim igi in X.i.3′ could refer to Mercury's morning first. This phenomenon is usually called kur *ša₂* nim = "eastern rising" or igi *ša₂* kur = "eastern appearance" (*BMAPT*, 57: Table 3.1), but the phrase *ina* nim igi, "it appears in the East," is also attested. Since the list ends with Cancer, the missing entries for Leo, Virgo, and Libra must have been written in X.i.1′–3′.

position	Sco	Sgr	Cap	Aqr	Psc	15 Ari	Tau	Gem	Cnc
value [$\overline{\tau}$]	14	12	12	12	18	37 or 38	35	[...]	22

Table 4: Control values of $\delta\tau$(EL to MF) [$\overline{\tau}$] mentioned in P1′.

P2′: Mercury system A_2, distance from morning last to evening first

The beginning of this procedure is broken off. What remains includes one intact rule (X.ii.5′–7′) "from B_1 until B_2 x," where B_1 and B_2 are zodiacal positions and x is a number. Remants of similar statements are preserved in the preceding lines (Table 5). The numbers for x can be securely identified as values of $\delta\Sigma$(ML to EF) connected to Mercury system A_2, similar to those reconstructed from the mentioned synodic table BM 36723+. If the other statements follow the same template, then $\delta\Sigma$(ML to EF) ought to be piecewise constant in each zodiacal region "from B_1 until B_2." In BM 36723+ $\delta\Sigma$(ML to EF) is indeed constant and equal to 58;30 UŠ in a region comprising at least Aquarius through Aries, consistent with X.ii.5′–7′, but in other regions linear interpolation between control values, including 52 UŠ (X.ii.1′), 1,14...1,18 UŠ (X.ii.4′), and 58;30 UŠ, appears to have been used. It is unclear whether P2′ prescribes piecewise constant values in each region or it included instructions for linear interpolation in some regions.

P3′: Mercury, time or distance between two synodic phenomena

The sparse remains of P3′ reveal little more than that it covers a similar topic to P1′ and P2′.

[10] For a new edition of this table see Ossendrijver 2025.

interval	$\delta\Sigma$(ML to EF) [UŠ]
[...] until [...]	52
[...] until 12 [...]	[...]
12 [...] until 20 Sgr	1,14...1,18
20 Sgr until 10 Gem	58;30

Table 5: Values of $\delta\Sigma$(ML to EF) [UŠ] mentioned in P2′.

P4′: unclear

This procedure consists of a single damaged line. The expression "equivalent of the year" (gaba.ri mu.an.na) is known from other planetary and lunar procedures, where it can denote the synodic time of a planet (*BMAPT* No. 18 P14: Jupiter) or the length of the year (*BMAPT* No. 95 P3′). The initial digit 6 is consistent with the expected values of τ for Jupiter (ca. 6,45$^{\overline{\tau}}$) or Saturn (ca. 6,24$^{\overline{\tau}}$), or some value of the year (e.g. 6,5 days).

P5′: a planet, subdivision of synodic cycle

The preserved text refers to the motion of a planet from the "day of appearance" until some other moment, presumably a synodic phenomenon, and a multiplication by 20. In the absence of parallels, this is insufficient for determining the meaning of the procedure.

III Text C (BM 41627): Moon, variant of system A

museum number	BM 41627 (81–6–25, 243)
provenience	Babylonia
date	ca. 400–50 BCE
measures	6.5(*) × 6.6(*) × 1.4–2.6 cm
arrangement	O/R
cuneiform text	Fig. 3
content	Moon, variant of system A

Transliteration

Obverse

1 ta *zib* en absin$_0$ 1.5⸢7$^{?}$⸣ [...]

2 ta absin$_0$ en *zib* 2.6.20 ⸢x⸣ [...]

3 5.28.29.25.⸢30⸣ nim *u* ⸢sig⸣ [...]

4 iti *ana* iti *lu-maš* a.ra$_2$ 4.0.5⸢7$^{?}$⸣ [... du ...]

5 *ša*$_2$ ⸢nim⸣ *u* sig du nim *u* sig a.ra$_2$ ⸢14.50$^?$ xx⸣ [...]
6 *a*-⸢*na*⸣ *lu-maš* du [...]

---

7 ⸢ta *zib*⸣ en absin$_0$ 20 la$_2$ ta absin$_0$ en *zib* nu tuk [...]
8 *ša*$_2$ mu nim *ša*$_2$ ⸢x⸣ [...]

---

9 [x] ⸢x⸣7.37.32.21.20 me ⸢3$^?$ x⸣ [...]
10 [x] ⸢xx⸣ du [...]

---

11 [xx] ⸢xx 30 30 xx 18$^?$⸣.30 ⸢x⸣ [...]

Reverse

1′ [xxxxxxx] ⸢xx 19$^?$ 3 x⸣ [...]
2′ [xxxxxx] ⸢x⸣ 2.30 GAR ⸢10$^?$⸣9 ⸢KA⸣ [...]
3′ [xxxx] ⸢zi⸣ *sin ina lu-maš* ⸢KI BAL$^?$⸣ [...]

Translation

Obverse

P1 1 From Pisces until Virgo 1,5⸢7$^?$⸣;[...]
2 From Virgo until Pisces 2,6;20 ⸢...⸣ [...]
3 5.28.29.25.⸢30⸣, the height and ⸢depth⸣ [...]
4 Month by month [you multiply] the “zodiacal sign” by 4.0.5⸢7$^?$⸣ [...]
5 you multiply [by ...] of ⸢height⸣ and depth, the height and depth times ⸢14.50$^?$ ...⸣ [...]
6 you multiply times the “zodiacal sign” [...]

P2 7 ⸢From Pisces⸣ until Virgo you subtract 20, from Virgo until Pisces nothing [...]
8 per year you put down (?) as the height ⸢...⸣ [...]

P3 9 [x] ⸢x⸣7.37.0.32.21.20 days(?) ⸢3$^?$ ...⸣ [...]
10 [x] ⸢...⸣ you multiply [...]

P4 11 [xx] ⸢... 30 30 ... 18$^?$⸣.30 ⸢...⸣ [...]

Reverse

P5′ 1′ [xxxxxxx] ⸢... 19$^?$ 3 ...⸣ [...]
2′ [xxxxxx] ⸢...⸣ 2.30 ... ⸢10$^?$⸣ 9 ⸢...⸣ [...]
3′ [xxxx] ⸢displacement⸣ of the Moon in the zodiacal sign(s) ⸢...⸣ [...]

Philological remarks

O1 ⸢7$^?$⸣: a reading 8 is also possible.

O2 ⸢x⸣: the beginning of a sign, perhaps two horizontal wedges.

O3 2⸢5.30⸣: the signs 5.30 are partly filled with dirt.

O4 ⸢7$^?$⸣: a reading 8 is also possible.

O5 ⸢14.50$^?$ xx⸣: the sign read as 50 might also be 40. It is followed by one or two instances of a 1, 4 or 7.

O6 *a*-⸢*na*⸣ *lu-maš* du: the most plausible interpretation is probably that *a-na* is a phonetically written a.ra$_2$ = "times, by," resulting in translation is "you multiply by the zodiacal sign."

O8 ⸢x⸣: the upper left corner of a sign such as LU.

O9 [x] ⸢x⸣7: the 7 is preceded by the upper end of a vertical wedge. 7.37.0.32.21.20: the 0 could also be interpreted as a separator, resulting in 7.37 : 32.21.20. ⸢3$^?$ x⸣: the 3 (or 2 BAR?) is followed by at least one *Winkelhaken* sign.

O10 ⸢x ŠU$_2$$^?$⸣: unidentifiable traces of one or two signs (x) followed by a sign similar to ŠU$_2$ partly filled with dirt.

O11 ⸢xx 30$^?$ 40$^?$ xxx 18$^?$⸣.30 ⸢x⸣: the 40 (or 50?) is followed by a numeral 4–8 and a second numeral or GAR, and unidentifiable traces of a third sign. The sign read as 8 may also be a 7. No interpretation can be offered.

R1′ 19$^?$: an anonymous referee is acknowledged for pointing out this plausible reading. 19 is preceded by faint traces of two signs. 3 is followed by traces of a *Winkelhaken* sign.

R2′ 2.30 is preceded by remains of a *Winkelhaken* sign. GAR ⸢10$^?$⸣9 KA: perhaps to be read *ša*$_2$ 19-*ka* = "of your 19 (years)," a phrase known from Goal-Year procedures.

R3′ ⸢KI BAL$^?$⸣: meaning unclear. In astronomical contexts KI usually stands for *itti* = with or *qaqqaru* = position; BAL for *palû* = period or *nabalkutu* = to transgress; exceed.

Commentary

This fragment preserves the upper left part of the obverse and the lower left part of the reverse of a tablet. Its curvature suggests that about two thirds of the original width and height are preserved. On the reverse tracks of an insect (trace fossils) are visible. According to the museum register, the tablet originates from Babylonia and was acquired from the dealer Spartali in 1881 (Leichty, Finkel and Walker 2019, 477). The collection 81–6–25 contains numerous astronomical tablets, including procedure texts. The fragment belongs to a compendium of lunar procedures, five of which are partly preserved. They are separated by horizontal rulings. The reverse is uninscribed, except for three lines at the top, which suggests that the tablet is unfinished. In combination with the careless ductus this may indicate that the tablet was written for short-term use. For a similar tablet with a largely uninscribed reverse see BM 34245+ (*BMAPT* No. 57). In the absence of a colophon and datable astronomical phenomena the date of writing cannot be estimated more precisely than ca. 400–50 BCE. P1 and P2 are concerned with the Moon and could be interpreted as precursors of lunar system A, which may suggest a relatively early date of writing (say ca. 400–330 BCE). However, the tablet could be a later copy of an original from that period and, moreover, it cannot be excluded that the procedures are not precursors to system A, but products of a later development. The other three procedures (P3, P4, P5′) are too badly damaged for a conclusive interpretation.

P1: Moon, variant of system A: distance to ecliptic

The instructions in O1–2 are suggestive of a step-function algorithm. As in lunar system A the zodiac is divided into two zones, but their boundaries are specified in an unusual manner. A consistent step-function algorithm can be obtained if "from Pisces until Virgo" (O1) is taken to mean from x Pisces until y Virgo and if "from Virgo until Pisces" (O2) is taken to mean from y Virgo until x Pisces, where x and y are values between 0 and 30 (recall that in system A $x = 27$ and $y = 13$). Moreover, there is no reference to transition rules, which should cause the quantity to assume a value in between the two constant ones whenever the Moon moves into a different zone in between two lunations. It therefore seems that the procedure is incompletely specified, or it is based on a step-function algorithm without transition rules. In each zone a number is provided, one with initial digits 1.57, and a second one starting with 2.6.20. A comparison with lunar system A yields a secure identification of these numbers as monthly differences of the Moon's distance to the ecliptic (latitude) at New Moon expressed in barleycorns, a unit corresponding to 1/72 (= 0;0,50) UŠ. In system A this quantity is represented by column E^{nm}, of which the monthly differences are $w_2 =$ 1,58;45,42 barleycorns and $w_1 =$ 2,6;15,42 barleycorns (*BMAPT*, 133–134). O3 mentions "height and depth," which is the technical term for distance to the ecliptic, consistent with the interpretation of O1–2. The preceding number, which may be read as 5.28.29.25.30, could not be identified. It is presumably a characteristic parameter of the algorithm.

O4 refers to a monthly update ("month by month"), consistent with the interpretation of O1–2, and a multiplication of the "zodiacal sign" (*lumāšu*) by a number. This is reminiscent of the system A relation between the Moon's latitudinal motion and its longitudinal motion with respect to the nodes,

$$w_j = 4 \cdot (\sigma_j - d_{\mathrm{node}}), \tag{3}$$

where j (= 1, 2) labels the zones of the step-function algorithm, σ_j is the Moon's synodic arc and $d_{\mathrm{node}} = -1;33,55,30$ UŠ is the monthly displacement of the lunar nodes (*BMAPT*, 137). It is plausible that O4 contains a variant of this relation. On that assumption, "zodiacal sign" (*lumāšu*) is a shorthand for the monthly change of the Moon's elongation from the nodes, $\sigma_j - d_{\mathrm{node}}$. In support of this interpretation it can be pointed out that there are other examples of common astronomical terms being used in a more specific sense. If correct, then 4;0,57[...] plays the same role as 4 in the system A algorithm.[11] Line O5 can be interpreted as the inverse procedure by which the Moon's monthly displacement from the lunar nodes is computed from the monthly change of latitude, which corresponds to

$$\sigma_j - d_{\mathrm{node}} = w_j/4 \tag{4}$$

in lunar system A. In Babylonian calculus, divisions are executed as multiplications by a reciprocal number. Replacing 4 by 4;0,57 or 4;0,58 yields an approximate reciprocal 0;14,56, which could explain the multiplication of "height and depth" by the number ⌜14.50$^{?}$...⌝ = (0);14,50$^{?}$... in O5 if "height and depth" is a shorthand for the monthly difference of that quantity (w_j). Line O6 appears to cover the same topic, but its meaning is not fully clear.

The procedure covers several aspects of an algorithm for computing the Moon's distance to the ecliptic from longitudinal displacements, but a complete set of rules for updating this quantity is not provided. A comparison with lunar system A indicates that this would require several additional steps (*BMAPT*, 133–138), no trace of which can be identified, nor is there enough room for them.

P2. Moon, variant of system A: zodiacal correction to duration of 12 synodic months?

The next procedure concerns a step-function algorithm for a quantity with the value 20, subtractive, from Pisces to Virgo, and 0 from Virgo to Pisces. These zodiacal signs presumably pertain to the same zonal boundaries that underlie the step-function algorithm of P1. It follows that the quantity is a zodiacal correction modeled as a step-function algorithm. A plausible interpretation can be inferred from the expression "per year" (O8), the numerical values –20 and 0, and a comparison with lunar system A. For convenience we first add 20, resulting in a modified step function with the value 0 from Pisces to Virgo and 20, additive, from Virgo to Pisces. This version is similar to Y in lunar system A (*BMAPT*, 157), which is a correction to Λ, the duration of 12 synodic months (*BMAPT*, 153–155). While Λ accounts only for the lunar variation of 12 synodic months, Y corrects for the zodiacal variation of this quantity. The system A version of Y that applies to full moons equals 0 from 13 Pisces to 27 Virgo and +21;2,59 UŠ from 27 Virgo to 13 Pisces. This strongly suggests that P2 deals with an analogous correction for the full moon case. However, a quantity corresponding to Λ is not preserved on the present tablet. In order to compensate for the 20 UŠ that were added, the mean value of the quantity corresponding to Λ should be about 20 UŠ smaller than in system A.

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[11] Alternatively one might interpret the 0 sign (*Glossenkeil*) as a separator, resulting in 4 : 5⌜7$^{?}$⌝[...], in which case 5⌜7$^{?}$[...] is the outcome of the multiplication, but this does not yield a meaningful statement.

The formulation of the procedure is similar to the beginning of the step-function templates ESTEP.A–D (*BMAPT*, 133–135). However, the expected transition rules for the case when the Moon crosses into the other zone in between two lunations are lacking. They would result in small longitudinal regions near the zonal boundaries where the correction assumes a value in between 20 and 0. The origin of the 20 remains unclear. In lunar system A the corresponding value $Y = +21;2,59$ UŠ is reproduced by adding twelve successive values of the quantity J, which represents the zodiacal correction to the duration of one synodic month (*BMAPT*, 157–158). But since no quantity analogous to J is attested on the present tablet this scenario cannot be verified.

P3: unclear

The number in O9 appears to be expressed in days. It is not attested elsewhere and could not be identified. If it begins with 7.37, assuming that the damaged sign before 7.37 does not belong to the number, and if it represents a longitudinal distance expressed in UŠ, then a very tentative interpretation can be suggested. In lunar system A the net difference of the Moon's elongation (η) from the ascending node after 235 months, which corresponds to 19 years, equals $d\eta(235) = 7;37,22,30$ UŠ in zone 2 and 7;36,22,30 UŠ in zone 1 for the New Moon case (*BMAPT*, 138). It seems possible that the number in O9 represents the same quantity. On that assumption P3 continues with the topic of lunar motion covered in P1 and P2.

P4: unclear

The first line of P4 is partly preserved. The meaning of the digits could not be established and there is insufficient text to infer the purpose of the procedure.

P5′: 19-year period and lunar motion

The reverse preserves sparse remains of three lines of a final procedure. R1′ contains a possible reference to a 19-year period, followed by a number starting with 3. Another possible reference to this period occurs in R2′, which might be interpreted as "... 2.30 of your 19 (years)," a formulation known from Goal-Year procedures. The 19-year period corresponds to 235 months, the interval tentatively identified in P3. The expression "displacement of the Moon" (R3′) is a technical term for the Moon's daily motion in longitude, corresponding to F in lunar systems A and B. However, the purpose of the procedure remains unclear.

IV Text D (BM 48142): Moon system A

museum number	BM 48142 (81–11–3, 851)
provenience	Babylon
date	ca. 350–50 BCE
measures	3.1(*) × 3.6(ca. 12) × 2.2–2.5 cm
arrangement	O/R
cuneiform text	Fig. 2
content	Moon system A, ΦG interpolation scheme, intervals 1–12, [13–35]; net differences of $\hat{G}$

Transliteration

Obverse

(perhaps 1 line missing)

1′ [*si-man*.meš *ana*] du$_3$-*ka* *ana* *tar*-[*ṣa* 2.13.20 la$_2$ 2.40 gar-*an* *ša$_2$* *al* 2.13.20 la$_2$ la$_2$ *ina* 2.13.20 nim]

2′ [*ša$_2$* tag$_4$] GAM 3.22.⌜30⌝ [du *ma-lu-uš-šu$_2$* 17.46.40 gar-*an* GAR.GAR-*ma* ki 2.40 tab-*ma* gar-*an*]

3′ [*ana tar*]-⌜*ṣa* 2.10.40⌝ la$_2$ ⌜2⌝.[53.20 gar-*an* *ša$_2$* *al* 2.10.40 la$_2$ la$_2$ *ina* 2.10.40 nim]

4′ [*ša$_2$*] tag$_4$ GAM 9.[20 du ki 2.53.20 tab-*ma* gar-*an*]

5′ [*ana tar*]-⌜*ṣa*⌝ 1.58.31.⌜6⌝.[40 la$_2$ 4.46.42.57.46.40 gar-*an* *ša$_2$* *al* 1.58.31.6.40 la$_2$ la$_2$ *ina* 1.58.31.6.40 nim *ša$_2$* tag$_4$]

6′ [a].⌜ra$_2$⌝ 8.20 du ⌜ki⌝ [4.46.42.57.46.40 tab-*ma* gar-*an*]

7′ [*ana tar*]-⌜*ṣa*⌝ 1.58.13.20 [la$_2$ 4.49.11.6.40 gar-*an* *ša$_2$* *al* 1.58.13.20 la$_2$ la$_2$ *ina* 1.58.13.20 nim *ša$_2$* tag$_4$]

8′ [a.ra$_2$] ⌜7.20 du⌝ [ki 4.49.11.6.40 tab-*ma* gar-*an*]

(about 15 lines missing)

Reverse

(about 16 lines missing)

1′ ⌜25.48⌝.38.⌜3⌝[1.6.40 *taš-pil-tu$_4$* ...]

2′ 50.10.51.51.[6.40 mu.du ...]

3′ [1].⌜26.25.1⌝[1.6.40 mu.du ...]

(perhaps 1 line missing)

Translation

Obverse

(perhaps 1 line missing)

P1 [1][In order for] you to construct [the durations.]

(1–9) Opposite [2,13;20, decreasing, you put 2,40. That which is less than 2,13;20, decreasing, you deduct from 2,13;20]; [2][what remains you multiply] by 3;22,30; [while it fills up you accumulate (0);17,46,40, and you add it with 2,40, and you put it down.]

(10) [3][Oppos]ite 2,10;40, decreasing, [you put] 2,[53;20. That which is less than 2,10;40, decreasing, you deduct from 2,10;40;] [4][what] remains you multiply by 9;[20, add with 2,53;20, and put down.]

(11) [5][Oppos]ite 1,58;31,6,[40, decreasing, you put 4,46;42,57,46,40. That which is less than 1,58;31,6,40, you deduct from 1,58;31,6,40, what remains] [6]you multiply by 8;20, [add] with [4,46;42,57,46,40, and put down.]

(12) [7][Oppos]ite 1,58;13,20, [decreasing, you put 4,49;11,6,40. That which is less than 1,58;13,20, decreasing, you deduct from 1,58;13,20, what remains] [8]⸢you multiply⸣ [by] ⸢7;20⸣, [add with 4,49;11,6,40, and put down.]

(about 15 lines missing)

Reverse

(about 16 lines missing)

P2 [1′]⸢25;48⸣,38,⸢3⸣[1,6,40, the difference. ...]

[2′]50;10,51,51,[6,40 it proceeds. ...]

[3′][1];⸢26,25,1⸣[1,6,40 it proceeds. ...]

(perhaps 1 line missing)

Philological remarks

O2′ GAM = "times" alternates with a.ra$_2$. *takammar*(GAR.GAR) = "you accumulate": for this additive expression see *BMAPT*, 21–22.

Commentary

This small fragment preserves a small portion from the upper left of the obverse and the lower left of the reverse of a tablet. No original edges are preserved, but only very little clay is missing on the left side and on the upper side of the obverse, corresponding to the lower side of the reverse. According to the registers of the British Museum it was excavated in Babylon by Hormuzd Rassam (Leichty, Finkel and Walker 2019, 656).

P1: Moon system A, computing G from Φ

P1 contains instructions for computing the duration of the synodic month (G) from the quantity Φ, which represents a zigzag sequence for the duration of the saros interval of 223 months, by means of a linear interpolation scheme. Both quantities are represented by a column in the synodic tables of lunar system A. For the meaning of Φ and G see *BMAPT*, 145–150. The complete interpolation scheme comprises 35 rules, each covering linear interpolation in one segment along the zigzag sequence of Φ. The obverse partly preserves instructions for intervals 1–12. The text is closely duplicated in BM 46116 (*BMAPT* No. 69). The instructions are divided into lines at exactly the same positions. Physical appearance of the tablet and ductus are also very similar. However, the two tablets are not identical duplicates. For instance, in O2′ multiplication is expressed with GAM, while *BMAPT* No. 69 uses the synonymous a.ra$_2$ at the equivalent position. Below O8′ about 15 additional lines must be restored, resulting in an original height of about 12 cm.

P2: Moon system A, net differences of $\hat{G}$

This procedure mentions three differences that characterize $\hat{G}$, which is a zigzag sequence for the duration of the synodic month that partly overlaps with G, namely its monthly difference $d = 25;48,31,6,40$ UŠ, net difference for 12 months, $d\hat{G}(12) = -50;10,51,51,6,40$ UŠ, and net difference for 14 months, $d\hat{G}(14) = 1;26,25,11,6,40$. For a discussion of G, $\hat{G}$, and these net differences, see *BMAPT*, 151. In the duplicate *BMAPT* No. 69 the same procedure immediately follows the interpolation rules (P1) and it ends with $d\hat{G}(14) = 1;26,25,11,6,40$. It is therefore likely that the tablet did not contain any other procedures and that no text is missing beyond R3′.

V Text E (BM 33582+33631 P3): Moon system A

museum number	BM 33582 (Rm4, 138) + 33631 (187)
provenience	Babylon
date	ca. 350–50 BCE
measures	6.9(8.0) × 12.0(13?) × 2.3–2.8 cm
arrangement	O/R
cuneiform text	Fig. 4
previous edition	BM 33582 unpublished; BM 33631: *BMAPT* No. 56
content	P3: Moon system A, computing C^{nm} from B^{nm}

Transliteration (P3)

Obverse

12 *ana tar-ṣa* (erasure?) ⌜10 ḫun 3 me *ša*$_2$ *al*⌝-[*la* 10 ḫun diri GAM 40 du-*ma*]

13 [ki] ⌜3 ḫun tab⌝-[*ma* gar-*an*]

14 *ana tar-ṣa* 10 mul$_2$ ⌜3.20⌝ [me *ša*$_2$ *al*]-⌜*la* 10 mul$_2$⌝ [diri GAM 24 du-*ma*]

15 [ki] ⌜3.20⌝ mul$_2$ [tab-*ma* gar-*an*]

16 *ana tar-ṣa* 10 maš.maš 3.⌜32⌝ [me *ša*$_2$] ⌜*al-la* 10 maš.maš diri⌝ [GAM 8 du-*ma*]

17 ki ⌜3⌝.32 maš.maš tab-*ma* [gar-*an*]

18 *ana tar-ṣa* 10 alla 3.36 me ⌜*ša*$_2$⌝ *al-la* 10 alla diri GAM ⌜8⌝ [du-*ma*]

19 ta ⌜3.3⌝6 alla nim-*ma* gar-[*an*]

20 *ana tar-ṣa* 10 a 3.32 me *ša*$_2$ *al-la* 10 a diri GAM 24 [du-*ma*]

21 ta 3.32 a nim-*ma* gar-⌜*an*⌝

22 *ana tar-ṣa* 10 absin 3.20 me *ša*$_2$ *al-la* ⌜10⌝ absin diri GAM 40 ⌜du⌝-[*ma*]

23 ta 3.⌜20 absin⌝ nim-*ma* gar-⌜*an*⌝

24 [*ana tar*]-*ṣa* 10 rin$_2$ 3 me *ša*$_2$ *al-la* ⌜10 rin$_2$ diri GAM 40⌝ [du-*ma*]

25 ⌜ta⌝ 3 rin$_2$ ⌜nim⌝-[*ma* gar-*an*]

Reverse

1 ⌜*ana tar-ṣa* 10 gir$_2$⌝.tab 2.40 me *ša*$_2$ *al-la* ⌜10 gir$_2$⌝.tab diri GAM 2[4 du-*ma*]

2 ta 2.40 gir$_2$.tab nim-*ma* [gar-*an*]

3 *ana tar-ṣa* 10 pa 2.28 me *ša*$_2$ *al-la* 10 pa diri GAM [8 du-*ma*]

4 ta 2.28 pa nim-*ma* [gar-*an*]

5 *ana tar-ṣa* 10 maš$_2$ 2.24 me *ša*$_2$ *al-la* 10 maš$_2$ [diri GAM 8 du-*ma*]

6 ki 2.24 maš$_2$ tab-*ma* [gar-*an*]

7 *ana tar-ṣa* 10 gu 2.28 me *ša*$_2$ *al-la* 1[0 gu diri GAM 24 du-*ma*]

8 ki 2.28 gu tab-*ma* [gar-*an*]

9 *ana tar-ṣa* 10 *zib*.me 2.40 me *ša*$_2$ *al*-[*la* 10 *zib*.me diri GAM 40 du-*ma*]

10 ki 2.⌜40⌝ [*zib*.me tab-*ma* gar-*an*]

Translation (P3)

Obverse

[12]Opposite ⌜10 Aries 3,(0), the daylight. (The amount) by which it [exceeds 10 Aries you multiply by (0);40 and] [13]⌜add⌝ [to] ⌜3,(0) for Aries [and put down.]

[14]Opposite 10 Taurus ⌜3,20⌝, [the daylight. (The amount) by which it exceeds] ⌜10 Taurus⌝ [you multiply by (0);24 and] [15][add to] ⌜3,20⌝ for Taurus [and put down.]

[16]Opposite 10 Gemini 3,⌜32⌝, [the daylight. (The amount) by which] ⌜it exceeds 10 Gemini⌝ [you multiply by (0);8 and] [17][add] to ⌜3⌝,32 for Gemini and [put down.]

[18]Opposite 10 Cancer 3,36, the daylight. (The amount) by which it exceeds 10 Cancer you [multiply] by (0);8 and [19]deduct from ⸢3,3⸣6 for Cancer and put down.
[20]Opposite 10 Leo 3,32, the daylight. (The amount) by which it exceeds 10 Leo [you multiply] by (0);24 [and] [21]deduct from 3,32 for Leo and put down.
[22]Opposite 10 Virgo 3,20, the daylight. The amount by which it exceeds ⸢10⸣ Virgo you ⸢multiply⸣ by (0);40 [and] [23]deduct from 3,⸢20 for Virgo⸣ and put down.
[24][Opposite] 10 Libra 3,(0), the daylight. The amount by which it ⸢exceeds 10 Libra⸣ [you multiply] ⸢by (0);40⸣ [and] [25]⸢deduct from⸣ 3,(0) for Libra [and put down.]

Reverse

[1]⸢Opposite 10 Scorpio⸣ 2,40, the daylight. The amount by which it exceeds 10 Scorpio you multiply by (0);2[4 and] [2]deduct from 2,40 for Scorpio and [put down.]
[3]Opposite 10 Sagittarius 2,28, the daylight. The amount by which it exceeds 10 Sagittarius you multiply by [(0);8 and] [4]deduct from 2,28 for Sagittarius and [put down.]
[5]Opposite 10 Capricorn 2,24, the daylight. The amount by which it [exceeds 10 Capricorn you multiply by (0);8 and] [6]deduct from 2,24 for Capricorn and [put down.]
[7]Opposite 10 Aquarius 2,28, the daylight. The amount by which it [exceeds 10 Aquarius you multiply by (0);24 and] [8]add to 2,28 for Aquarius and [put down.]
[9]Opposite 10 Pisces 2,40, the daylight. The amount by which it [exceeds 10 Pisces you multiply by (0);40 and] [10][add] to 2,40 for [Pisces and put down.]

Philological remarks

O19 gar-[*an*], "you put down": preserved on the newly joined fragment.

O21 gar-⸢*an*⸣, "you put down": preserved on the newly joined fragment.

Commentary

BM 33582 is a small fragment that joins BM 33631 (*BMAPT* No. 56) on the right side of O16–24. It does not preserve any edges of the original tablet, but at most a few mm of clay are missing from its right and lower edges. According to the registers of the British Museum both fragments were excavated in Babylon by Hormuzd Rassam (Leichty, Finkel and Walker 2019, 208). The complete tablet contained three procedures (P1–P3) belonging to lunar system A. The present edition only covers P3 (O12–R10). For further information about the tablet and editions of the other procedures see *BMAPT* No. 56.

P3: Moon system A, computing C^{nm} from B^{nm}

This procedure comprises twelve instructions for computing the duration of daylight (C^{nm}) from the longitude of new moon (B^{nm}) by means of linear interpolation with respect to control points located at 10 UŠ of the zodiacal signs. For more information about the procedure see *BMAPT*, 40–42 (interpolation) and 130–131 (*C*). The instructions are formulated in accordance with the templates IP.A.1 and IP.A.2 (*BMAPT*, 41). The new fragment reveals that the rules for Cancer and Leo, and by implication also those for the other signs, end with the phrase "and you put it down." In the previous edition they were thought to end with tab-*ma* = "you add, and" or nim-*ma* = "you subtract, and," which is syntactically problematic, because -*ma* usually coordinates two actions, as is now confirmed.

VI Text F (BM 33451+47744+47924+49084 P2, T1): Moon system A

museum number	BM 33451 (Rm4, 5) +47744 (81–11–3, 449) +47924 (631) +49084 (1795)
provenience	Babylon
date	ca. 350–50 BCE
measures	6.0(ca. 8.0) × 10.8 × 2.0–2.8
arrangement	O/R
publication	BM 49084: unpublished; BM 33451+47744+47924: *BMAPT* No. 61.D
cuneiform text	Fig. 5
content	P2, T1: Moon System A, Lunar Six interval NA

Transliteration (P2, T1)

Obverse

16 na *ana* du$_3$-*ka* *ki-i si-man* *ša*$_2$ gi$_6$ du [*al-la* la$_2$ *ša*$_2$ gi$_6$ *i-ṣi* gi$_6$ du ta la$_2$ *ša*$_2$ gi$_6$ nim]

17 ⌜*ša*$_2$ tag$_4$⌝ me *ina* me-*šu*$_2$ *ki-i si-man* *ša*$_2$ gi$_6$.[du *al-la* la$_2$ *ša*$_2$ gi$_6$ diri la$_2$ *ša*$_2$ gi$_6$ ta gi$_6$ du nim]

18 *ša*$_2$ tag$_4$ ⌜ta 6 la$_2$ 1-*en*⌝ me tab *ša*$_2$ tag$_4$ ⌜a⌝.[ra$_2$ 10 du *ša*$_2$ e$_{11}$-*ma* *šu-u*$_2$ zi *šamaš*$_2$ gar-*an* a.ra$_2$ zi *sin*]

19 ⌜*ša*$_2$⌝ iti-*šu*$_2$ ⌜du⌝-[*ma šu*]-⌜*u*$_2$⌝ zi *sin* gar-*an* [zi *šamaš*$_2$ ta zi *sin* nim BE gar-*an* ki *sin u* ki *šamaš*$_2$ gar-*an*]

20 ⌜zi *ša*$_2$⌝ *šamaš*$_2$ ⌜zi⌝ [ki ki *šamaš*$_2$ tab zi *ša*$_2$ *sin* zi ki ki *sin* tab ki *sin u* ki *šamaš*$_2$ *ša*$_2$ *al-la*]

21 ⌜10 *lu*⌝-*maš* diri a.ra$_2$ ⌜16⌝ [du ki bar.n]un *ša*$_2$ *lu-maš* *ša*$_2$-*šu*$_2$ ⌜*ki*⌝-[*i* tab tab *ki-i* la$_2$ la$_2$]

22 ⸢*ana*⸣ ugu *a-ḫa-miš*$_2$ GAR.GAR-⸢*ma*⸣ [1/2-*šu*$_2$-*nu* GIŠ].⸢A⸣ *ana* bar.nun gar-*an* ni[m *u* sig *ša*$_2$ *sin* gar-*an* zi *sin*]

23 a.ra$_2$ 4 du ki ⸢nim⸣ [*u*] ⸢sig⸣ *ša*$_2$ *sin* (erasure) ⸢*ki-i*⸣ tab tab *ki*-[*i* la$_2$ la$_2$]

24 ki *sin* ⸢*u* ki⸣ [*šamaš*$_2$ *ša*$_2$] ⸢*al*⸣-*la* 10 *lu-maš* ⸢diri⸣ a.ra$_2$ ⸢8⸣ d[u ki bar.nun *ša*$_2$ nim *u* sig *ša*$_2$-*šu*$_2$]

25 ⸢*ki-i*⸣ [tab tab *k*]*i*-⸢*i*⸣ la$_2$ la$_2$ *ana* ugu *a-ḫa-miš*$_2$ GAR.GAR-⸢*ma*⸣ [1/2-*šu*$_2$-*nu* GIŠ-*ma* a.ra$_2$ DIŠ.UD *ša*$_2$ nim *u* sig]

26 [*ša*$_2$] ⸢gar-*un*⸣ du BE a.ra$_2$ bar.nun du *ki-i* la$_2$ *ana* BE *u* bar.nun [tab *ki* sig *ana* BE *u*$^?$ bar.nun$^?$ la$_2$ *ana* na e]

27 *ki-i* DIŠ.UD ⸢*ša*$_2$ nim⸣ [*al*]-*la* BE *u* bar.nun diri-*at* BE *u* [bar.nun ta *lib*$_3$-*bi* nim *ša*$_2$ tag$_4$ *ana* šu$_2$ e]

28 na *ana* šu$_2$ gur ⸢me⸣ [nu man-*ni* 6 ki] ⸢*si*⸣-*man* igi-*u*$_2$ tab gin$_7$ [igi-*u*$_2$ du$_3$-*uš* 1-*en* me tab *ana* na e]

Reverse

1	[ba]r.nun *ša*$_2$ *lu-maš* *ša*$_2$ šu$_2$				bar.nun *ša*$_2$ [nim *u* sig *ša*$_2$ šu$_2$]			
2	⸢1⸣.24	ḫun	44	gir$_2$.tab	18	ḫun	[42	rin$_2$]
3	1.16	mul$_2$	52	pa	22	mul$_2$	[36	gir$_2$.tab]
4	1.8	maš	1	maš$_2$	26	maš	[34	pa]
5	1	alla	1.8	gu	30	alla	[30	maš$_2$]
6	52	⸢a⸣	1.16	*zib*.me	34	a	[26	gu]
7	44	⸢absin⸣	1.24	ḫun	38	absin	[22	*zib*.me]
8	36	rin$_2$						

Translation (P2, T1)

P2 [16]In order for you to construct NA.

(1) If the time by which the night has progressed [is less than the duration of the night you deduct (the time by which) the night has progressed from the duration of the night.] [17]What remains: the day (of NA) is on that day. If the time by which the night has progressed [exceeds the duration of the night, you deduct the duration of the night from (the time by which) the night has progressed]. [18]What remains you subtract from 6,(0). You add one day.

(2) What remains you multiply by [(0;0),10, what comes out, this you put down as the displacement of the Sun.] You multiply it [by the Moon's displacement] [19]for that month, [and] this you put down as the displacement of the Moon.

(3) [You subtract the displacement of the Sun from the displacement of the Moon, and you put it down as the elongation.]

(4) [You put down the position of the Moon and the position of the Sun.] [20]The displacement by which the Sun moved [you add to the position of the Sun. The displacement by which the Moon moved you add to the position of the Moon.]

(5) [The position of the Moon and the position of the Sun: (the amount by) which] [21]they exceed 10 of the zodiacal sign [you multiply] by (0;0),16. [You add it with the] corresponding [*ṣiliptu*-coefficient] for the zodiac if [it is increasing, subtract if it is decreasing.] [22]You accumulate (them) together, and [you compute half of it,] and you put it down as the *ṣiliptu*-coefficient.

(6) [You put down the Moon's 'height and depth'. The displacement of the Moon] [23]you multiply by (0);4. You add it with the Moon's 'height [and] depth' if it is increasing, [subtract if it is decreasing.]

(7) [24]The position of the Moon and the position of [the Sun: (the amount) by which] they exceed 10 of the zodiacal sign you multiply by (0;0),8. [You add it with the corresponding *ṣiliptu*-coefficient for 'height and depth'] if [it is increasing], subtract if it is decreasing. You accumulate (them) together, [you compute half of it, and]

(8) you multiply it [by the DIŠ.UD of 'height and depth' [26]which] you had put down.

(9) You multiply the elongation by the *ṣiliptu*-coefficient.

(11) If (the Moon) is 'high' [you add] it to the elongation and the *ṣiliptu*-coefficient. [If it is 'low' you diminish the elongation and the *ṣiliptu*-coefficient by it. You call it NA.]

(12) If the DIŠ.UD of 'height' (error for 'depth') exceeds the elongation 'and' the *ṣiliptu*-coefficient, [you deduct] the elongation ['and' the *ṣiliptu*-coefficient from it. What remains you call ŠU$_2$.] [28] NA becomes ŠU$_2$. [You do not change] the day.

(13) You add [6,(0) to] the previous time, you do as [before. You add one day. You call it NA.]

Reverse

	T1.a				T1.b			
1	*Ṣiliptu*-coefficient for the zodiac for setting				*Ṣiliptu*-coefficient for 'height and depth' for setting			
2	⌜1⌝;24	Ari	(0);44	Sco	(0);18	Ari	[(0);42	Lib]
3	1;16	Tau	(0);52	Sgr	(0);22	Tau	[(0);36	Sco]
4	1;8	Gem	1	Cap	(0);26	Gem	[(0);34	Sgr]

5	1	Cnc	1;8	Aqr	(0);30	Cnc	[(0);30	Cap]
6	(0);52	Leo	1;16	Psc	(0);34	Leo	[(0);26	Aqr]
7	(0);44	Vir	1;24	Ari	(0);38	Vir	[(0);22	Psc]
8	(0);36	Lib						

Philological remarks

O19 The beginning of this line was previously (*BMAPT*, 400) reconstructed as zi *sin* (these signs are now reconstructed at the end of O18).

O20 The beginning of this line was previously (*BMAPT*, 400) reconstructed as ki *sin u* ki *šamaš$_2$* gar-*an* (these signs are now reconstructed at the end of O19).

O21 The beginning of this line was previously (*BMAPT*, 400) reconstructed as tab ki *sin u* ki *šamaš$_2$ ša$_2$ al-la* (these signs are now reconstructed at the end of O20).

O23 The beginning of this line was previously (*BMAPT*, 400) reconstructed as gar-*an* zi *sin* (these signs are now reconstructed at the end of O22).

Commentary

BM 49084 is a small fragment that joins BM 33451+47744+47924 (*BMAPT* No. 61.D) on the left edge. According to the registers of the British Museum BM 33451 and BM 49084 were excavated in Babylon by Hormuzd Rassam (Leichty, Finkel and Walker 2019, 208, 656). For the other two fragments no provenance is reported. For further information about the tablet see *BMAPT*, 395, 417–419 (No. 61.D). The complete tablet contained four procedures connected to lunar system A for computing the Lunar Six intervals ŠU$_2$ (P1), NA (P2), ME (P3), and GI$_6$ (P4). For definitions of these intervals see *BMAPT*, 113–114. The new fragment preserves the beginning of O17–25 (P2) and R2–5 (T1.a).

P2: Moon system A, Lunar Six interval NA

The interval NA corresponds to the time between sunrise and moonset near full moon. The procedure is divided into thirteen steps which are indicated in the left margin of the translation. The auxiliary table (T1) contains coefficients that are used in the procedures. For a detailed commentary and explanation see *BMAPT*, 161–178, 419–420. The new fragment confirms the previously reconstructed text, except that the division into lines is different here and there (see the philological remarks).

VII Text G (BM 35099+35125): Moon system A

museum number	BM 35099 (Sp2, 640) +35125 (671)
provenience	Babylon
date	ca. 350–50 BCE
measures	9.3(x) × 5.2(*) × 2.0(*)
publication	BM 35099: unpublished; BM 35125: *BMAPT* No. 61.F
cuneiform text	Fig. 6
content	Moon System A: Lunar Six intervals ŠU$_2$, NA, [ME, GI$_6$]

Transliteration

Obverse?

(about 5 lines missing)

1′ [xxxx nim *u* sig *ša*$_2$ *sin* gar]-⸢*an* zi *sin*⸣ [GAM 4] ⸢du⸣ [ki nim *u* sig *ša*$_2$ *sin*]

2′ [*ki* tab la$_2$ *ki* la$_2$ tab *qaq-qar sin u*]⸢*qaq*⸣-*qar šamaš*$_2$ *ša*$_2$ 10 *lu-maš* [diri gam 8 du ki bar.nun *ša*$_2$]

3′ [nim *u* sig *ša*$_2$-*šu*$_2$ *ki* tab tab *ki*] ⸢la$_2$ la$_2$⸣ GAM DIŠ.UD *ša*$_2$ nim *u* ⸢sig⸣ [*ša*$_2$ *taš-kun* du BE GAM bar.nun du]

4′ [*ki* nim *a-na* BE la$_2$ *ki* sig] ⸢*a-na* BE⸣ tab *a-na* šu$_2$ me ⸢GAR$^?$⸣ [x *ki* DIŠ.UD]

5′ [*ša*$_2$ nim *al-la* BE *u* bar.nun] ⸢x diri$^?$ BE *u*$_3$ bar.nun⸣ ta *lib*$_3$-*b*[*i* nim *a-na* na me]

6′ [me nu man-*ni* 6 ki *si*]-⸢*man* igi⸣-*u*$_2$ tab ⸢*ki* igi⸣-*u*$_2$ ⸢du$_3$⸣-*uš* 1-*en* me ⸢la$_2$⸣ [*a-na* šu$_2$ me]

7′ [na *a-na* du$_3$-*ka ki si-man ša*$_2$] ⸢gi$_6$ du *al*⸣-*la* la$_2$ *ša*$_2$ gi$_6$ *i-ṣi* gi$_6$ du ta la$_2$ *ša*$_2$ [gi$_6$ nim]

8′ [*ša*$_2$ tag$_4$ me *ina* me-*šu*$_2$ *ki si*]-*man ša*$_2$ ⸢gi$_6$⸣ du *al-la* la$_2$ *ša*$_2$ gi$_6$ diri ⸢la$_2$ *ša*$_2$ gi$_6$ ta gi$_6$⸣ [du nim]

9′ [*ša*$_2$ tag$_4$ ta 6 la$_2$ 1-*en*] ⸢me⸣ tab *ša*$_2$ tag$_4$ GAM 10 ⸢du⸣ *šu-u*$_2$ z[i *šamaš*$_2$ gar-*an* GAM zi *sin ša*$_2$ iti-*šu*$_2$ du-*ma*]

10′ [*šu-u*$_2$ zi *sin* gar-*an*] zi *šamaš*$_2$ ta zi *sin* ⸢nim⸣-*ma* BE ⸢gar⸣-[*an* ki *sin u* ki *šamaš*$_2$ gar-*an*]

11′ [xxxxxxxx *a*]-*na muḫ-ḫa a*-⸢*ḫa-a-miš*$_2$⸣ [GAR.GAR-*ma* 1/2-*šu*$_2$-*nu* GIŠ-*ma a-na* bar.nun gar-*an*]

12′ [xxxxxxxx] ⸢*ša*$_2$$^?$ *al*⸣-*la* 10$^?$ ⸢*lu*$^?$⸣-[*maš* diri xxxxxxxxxxxxxx]

13′ [xxxxxxx nim *u*] ⸢sig⸣ *ša*$_2$ ⸢x⸣ [xxxxxxxxxxxxxxxxx]

(at least 3 lines missing)

Translation

P1 (about 5 lines with steps 1–5 are missing)

(6) $^{\mathrm{O}1'}$You put [down the Moon's 'height and depth'.] The displacement of the Moon you multiply [by (0);4. $^{2'}$You subtract it from the Moon's 'height and depth' if it is increasing, add if it is decreasing.]

(7) [The position of the Moon and] the position of the Sun, (the amount) by which they [exceed] 10 of the zodiacal sign [you multiply by (0;0),8. $^{3'}$You add it with the corresponding *ṣiliptu*-coefficient for 'height and depth' if it is increasing], subtract [if] it is decreasing.

(8) [You multiply] it by the DIŠ.UD of 'height and depth' [which you had put down.]

(9) [You multiply the elongation by the *ṣiliptu*-coefficient.]

(11) $^{4'}$[If (the Moon) is 'high' you diminish the elongation by it. If it is low] you add it to the elongation. You call it ŠU$_2$. ... [...]

(12) [If the DIŠ.UD] $^{5'}$[of 'height'] exceeds [the elongation and the *ṣiliptu*-coefficient you subtract] the elongation from it. [You call it NA.] $^{6'}$[You do not change the day.]

(13) You add [6,(0) to] the previous time, you do as before. You subtract one day. [You call it ŠU$_2$.]

P2 $^{7'}$[In order for you to construct NA.]

(1) [If the time by which] the night has progressed is less than the duration of the night you [deduct] (the time by which) the night [has progressed] from the duration of the night. $^{8'}$[What remains: the day (of NA) is on that day. If] the time by which the night has progressed exceeds the duration of the night, you [deduct] the duration of the night from (the time by which) the night [has progressed]. $^{9'}$[What remains you subtract from 6,(0).] You add [one] day.

(2) What remains you multiply by (0;0),10, this you put down as the displacement [of the Sun. You multiply it by the Moon's displacement for that month, and], $^{10'}$[this you put down as the displacement of the Moon.]

(3) You subtract the displacement of the Sun from the displacement of the Moon, and you put it down as the elongation.

(4–5?) $^{11'}$[... You accumulate] (them) together, [you compute half of it, and you put it down as the *ṣiliptu*-coefficient.]

(6–7?) $^{12'}$[... The position of the Moon and the position of the Sun:] (the amount) by which [they exceed] 10(?) of the zodiacal(?) [sign(?) ...]

(8?) $^{13'}$[... height and] ⌜depth⌝ which [you] ⌜put⌝ [down ...]

(at least 3 lines with steps 9–13 are missing)

Philological remarks

O6′ [*si*]-⌜*man* igi⌝: partly preserved on the new fragment.

O9′ *ša₂* tag₄ GAM 10 ⌜du⌝, "that which remains you multiply by (0;0),10": preserved on the new fragment. It is not followed by the expression *ša₂* e₁₁-*ma*, "what comes out," as assumed in *BMAPT*, 398 (No. 61.F step 2). This expression is also omitted in step 2 of some other Lunar Six procedures, e.g. BM 35399 (*BMAPT* No. 61.A) P1 (ŠU₂).

O10′ The new fragment confirms the reconstruction in *BMAPT*, 400 (No. 61.F P2 steps 2 and 3).

O11′ [*a*]-*na muḫ-ḫa*: this phonetic writing of *ana muḫḫi*, "to; on top of," is not attested in any duplicate. The expression belongs to step 5, but there is insufficient room for step 4 and the beginning of step 5 (see the commentary).

O12′ Except for the sign *la* all readings are very uncertain. The sign read as 10? could also be 20 or a *Glossenkeil* (GAM). The preserved text points to step 5 or step 7, but there is no room for step 6, which is expected to precede it.

O13′ ⌜sig⌝ *ša₂* ⌜x⌝: *ša₂* is followed by very faint traces.

Commentary

BM 35099 is a small fragment that joins BM 35125 (*BMAPT* No. 61.F) on the left side. It does not preserve any edges of the original tablet. Both are inscribed on one side, which is assumed to be the obverse; the other side is destroyed. For further information about the tablet see *BMAPT*, 417–419 (No. 61.F). The combined fragments partly preserve two procedures for computing the Lunar Six intervals ŠU₂ (P1) and NA (P2). The complete tablet probably continued with procedures for ME (P3) and GI₆ (P4). BM 35099 adds a few signs at the beginning of O6′ (P1) and more substantial portions of text at the beginning of O7′–13′ (P2).

P1: Moon system A, Lunar Six interval ŠU₂

This procedure is concerned with the Lunar Six interval ŠU₂, which is the time from moonset to sunrise for the last moonset near full moon that happens before sunrise (*BMAPT*, 113–114). The procedure is divided into thirteen steps, which are indicated in the left margin of the translation. For a detailed commentary see *BMAPT*, 161–178, 396–399 (No. 61 P1), and 419–420. The only change to the previous edition concerns the beginning of O6′, where the new fragment preserves traces of two signs belonging to step 13. They confirm the previous reconstruction of this step.

P2: Moon system A, Lunar Six interval NA

This procedure is concerned with the Lunar Six interval NA, the time from sunrise to moonset for the first sunrise near full moon that happens before moonset (*BMAPT*, 113–114, 161–178, 399–405). Following *BMAPT* it is divided into thirteen steps, which are indicated in the left margin of the translation. The new fragment adds text near the beginning of O7′–13′ (steps 1–8). Since the text of P1 is fully consistent with the duplicates, one would expect the same for P2. This is true for O7′-10′ (steps 1–3), but beyond O10′ the text deviates. However, the gaps are too large for a convincing reconstruction.

Steps 1–3 The additional text in O7′–10′ is consistent with the reconstruction in *BMAPT* No. 61.F, except that the phrase "what comes out" is omitted from step 1 (see the philological remarks). The interpretation of steps 1–3 is not affected.

Steps 4–8? The preserved text in O11′–13′ differs from the duplicates (*BMAPT* No. 61.ABDEG P2). The expression *ana muḫḫa aḫāmiš*, "(you accumulate them) together," points to step 5 where two values of the coefficient q, one for the Moon and one for the Sun, are averaged (*BMAPT*, 168–169). The end of O11′ has been tentatively reconstructed in accordance with step 5 based on the duplicates. However, there is insufficient room for the beginning of step 5 and, before that, step 4. Some abbreviated version of steps 4–5 must have been written in O10′–11′, but it is unclear how it might have been formulated. A possible abbreviation is obtained if q is computed from the Moon's longitude at opposition, in which case the solar and lunar values of q would coincide. In that case step 4 could be omitted and there would be no need for averaging solar and lunar values of q in step 5. However, the expression "[you accumulate them] together" belongs to the averaging procedure, so that this shortcut can be ruled out. It is therefore unclear what was written in the missing parts.

One would expect step 5 to be followed by step 6 in which the Moon's distance to the ecliptic is modified by adding or subtracting a correction to account for the change of this distance between the moment of opposition and the sunrise of NA (*BMAPT*, 169–170). No trace of step 6 could be securely identified in O12′–13′, but it could be reconstructed at the beginning of O12′. The text preserved in O12′ rather points to step 5 or step 7, in which two values of the coefficient r, one for the Moon and one for the Sun, are averaged (*BMAPT*, 170–171). Step 5 can be ruled out, because the text in O12′ should precede the part of step 5 preserved in O11′. Step 7 is therefore most likely, although this interpretation is not entirely without problems, because there is little room at the beginning of O12′ for step 6 and the beginning of step 7, if they are formulated in the same manner as in the duplicates (*BMAPT*, 400–403). The traces in O13′ are tentatively consistent with step 8, which deals with the contribution to NA resulting from the Moon's distance to the ecliptic (*BMAPT*, 172, 402–403).

VIII Text H (BM 36722+37205+40082 +unnumbered fragment + Rm4, 748): Moon system K

museum number	BM 36722 (80–6–17,455) +37205 (958) +40082 (81–2–1,47) + unnumbered BM fragment 5.2 (R.i.17–25) + Rm4, 748 (O.ib.1–2, ii.1–3, LE.3–4)
provenience	Babylon
date	ca. 330–300 BCE?
measures	12 × 19 × 3.3 cm
publication	unnumbered fragment 5.2; Rm4, 748: unpublished; BM 36722+37205+40082: *BMAPT* No. 52
cuneiform text	unnumbered fragment 5.2: Fig. 4; Rm4, 748: https://www.ebl.lmu.de/fragmentarium/Rm-IV.748
content	Moon system K; colophon

Transliteration

Obverse column ib

1 ḫun 5 tab 10 ⸢zi⸣

2 ⸢mul$_2$⸣ 5 tab 1[1] ⸢zi⸣

Column i

41 gu$_4$ 1 31 na e-*bi* *mi-nu-u$_2$* gi$_6$

42 du en.nun gi$_6$ ta ša$_3$ zi-*ma* *ša$_2$* tag$_4$

43 ⸢a.ra$_2$ zi⸣ *ša$_2$* iti-*šu$_2$* du-*ma* ki 31 tab

Column ii

1 *mi-nu-u$_2$* ⸢*ki*⸣-[*i* xxxxx] ⸢1 30⸣ [x]

2 *ki-i* gi$_6$ du [*al-la* en.nun gi$_6$ *i-ṣi* x] ⸢na?-*su*$^?$⸣ [x]

3 *mi-nu-u$_2$* *ki-i* *ana* kur *šamaš$_2$* ⸢*re*⸣-*ḫi* a.ra$_2$ zi

4 *ša$_2$* iti-*šu$_2$* du-*ma* ta na *ša$_2$* gu$_4$ zi *ki-i*

Reverse column i

17 [27 15.16 kur *ša$_2$* bar d]u$_{11}$ diri.še 30 ⸢2⸣[1 na]

18 [*ki-i an*]-⸢*na-a*⸣ [tab 11 tab] ⸢*ša$_2$*⸣ *zib* 14 tab *ša$_2$* ⸢ḫun *bi-rit*⸣

19 [tab *ana* tab 3 : 3] ⸢*a-na*⸣ [30 še]š.meš sum-*ma* igi 30

20 ⸢2⸣ [: 2 a.ra$_2$ 3 6 1] ḫun *mi-nu-u$_2$* *al* 12

21 ⸢ḫun⸣ la$_2$-⸢*u$_2$*⸣ 11 ⸢la$_2$⸣ [11 a].ra$_2$ 6 du-*ma* 1.6

22 ta 14 tab *ša$_2$* ḫ[un zi]-⸢*ma*⸣ tag$_4$ 12.54

23 ki diri.še ⸢30 2⸣1 tab-*ma* 33.54 gar-*an*

24 bar 1 33.[54] ⸢na⸣ gar-*an* du$_{11}$.ga gur-*ma* diri.še
25 ⸢*mi*⸣-[*nu-u*$_2$] ⸢ta⸣ ša$_3$ *lu-us-suḫ zib* 18 zi
Lower edge
3 $^{\text{m}}$mu-$^{\text{d}}$en ⸢a⸣ [xx] ⸢DIRI$^?$ *ṭup-pi*⸣ [xxxxx] ⸢*la*⸣-*bi-ri-šu*$_2$ [x]
4 [*ina a*]-*mat* $^{\text{d}}$en $^{\text{d}}$gašan-ia$_2$ ⸢en$^?$⸣.meš dingir.meš *ša*$_2$ an-*e u* [ki-*tim*]
mim-ma du$_3$-*uš ina* šu.2-⸢*a*⸣ [*liš-lim* xxxxxxx]

Translation

T2 (O.ib.1–2)

1	Aries	5	add	10	⸢subtract⸣
2	⸢Taurus⸣	5	add	1[1]	⸢subtract⸣

P2 (O.i.41b–43, ii.1–4)

step 3 $^{\text{O.i.41b}}$Whatever (the time by which) the night has progressed (M): ^{42}you subtract (‘tear out’) the ‘watch’ of the night (D) from it, and what remains ^{43}you multiply by the displacement for that month (ZI), and you add it with 31. $^{\text{O.ii.1}}$Whatever [...] ⸢1 30⸣ [...] ^{2}If (the time by which) the night has progressed (M) [is less than the ‘watch’ of the night (D): ...] ^{3}Whatever remains until sunset ^{4}you multiply by the displacement for that month, and you ‘tear it out’ from NA$_1$ of month II.

P4.d (R.i.17b–25)

step 1 $^{\text{R.i.17b}}$Month XII$_2$, (which began on day) 30 (of the previous month), [NA$_1$ is] 2[1.] ^{18}⸢Thus⸣ [is the addition: the addition] for Pisces is [11], the addition for Aries is 14, the distance ^{19}[from addition to addition is 3.] You divide [3 into 30] parts: the reciprocal of 30 ^{20}is ⸢(0);2⸣ [: (0);2 times 3 is (0);6. 1] Aries: whatever (the amount) by which ^{21}it is less than 12 Aries: it is less by 11. You multiply [11] by (0);6, it is 1;6. ^{22}[You ‘tear out’] 1;6 from 14, the addition for ⸢Aries⸣, and there remains 12;54. ^{23}You add 12;54 with month XII$_2$, (which began on day) ⸢30 (of the previous month), 2⸣1, and you put down 33;54. ^{24}You put down, predict 33;[54] as NA for month I day 1 (following a full month).

step 2 (In case) it is hollow, month XII$_2$: ^{25}what should I ‘tear out’ from it? Pisces: the subtraction is 18. (...)

Colophon (LE.3–4)

Col. $^{\text{LE.3}}$Iddin-Bel, son of [...] ..., tablet [... according to] an older version [...] ^{4}[At] the command of Bel and Beltija, the lords ? (and) the gods of heaven and [earth.] May whatever I make with ⸢my⸣ hands [go well ...]

Philological remarks

R.i.22 ta 14: replaces [1.6 ta 14] (*BMAPT*, 348).

R.i.23 ki diri.še ⸢30 2⸣1: replaces [12.54 ki 21] (*BMAPT*, 348).

LE.3 [xx] ⸢DIRI?⸣: reading uncertain; perhaps part of the filiation. Alternatively DIRI may belong to *u₂-šeš-ṭir* = 'had it written'.

LE.4 du₃-*uš*: possible Akkadian readings are *eppuš* = I make (1st p. sg. pret. and *lūpuš* "I may make." ⸢*a*⸣: the initial vertical wedge is preserved.

Commentary

Two previously unpublished small fragments from the British Museum are joins to this tablet. An unnumbered fragment ("5.2") of approximate size 2.5 × 4.2 cm joins BM 36722 on the left edge of the reverse. It was identified in 2004 in a box with unnumbered fragments from the Babylon collection thought to have astronomical contents.[12] It preserves the beginning of lines R.i.18–25, which belong to P4.d step 1 (R.i.17–24) and step 2 (R.i.24–31). The fragment Rm4, 748 of approximate size 2.3 × 1.3 × 1.0 cm directly joins BM 36722 on the upper (lower) edge of the obverse (reverse). This join was identified by Zsombor Földi (EBL project, Munich) in 2024. It preserves traces of the final sign in O.i.1–2 (T2), the beginning of O.ii.1–3 (P2), and a portion of the colophon. The present edition only covers the parts of the tablet that are affected by the joins (O.i.1–2, ii.1–3, i.41–43, ii.1–4, R.i.17–25, and LE.3–4). The newly added fragments affect two procedures (P2, P4.d) for computing the Lunar Six interval NA_1 in accordance with system K. Recall that NA_1 is the time between sunset and the setting of the first crescent after New Moon, which marks day 1 of the new month. Also affected is a table (T2) with coefficients for computing the Lunar Six intervals NA_1 and KUR. For detailed explanations see *BMAPT*, 116–121, and No. 52. For the previously known fragments and further information about the tablet see *BMAPT*, 417–419 (No. 52).

T2: coefficients for computing NA_1 and KUR

Table T2 (O.ib.1–13) contains values of two coefficients, TAB_2 and ZI_2, which are used in steps 1 and 2 of the procedure for computing NA_1 and KUR (*BMAPT*, 119–120, 352). The fragment Rm4, 748 preserves the end of the sign zi in O.ib.1–2, confirming the previously reconstructed text.

P2: NA_1, step 3

P2 (O.i.41b–43, O.ii.1–4) contains exemplary implementations of step 3 of a procedure for computing NA_1. Step 3 concerns a correction to the preliminary value of

[12] In 2004 five such boxes were present in the British Museum. The fragment was found in box 5.

NA_1 obtained in steps 1–2 (*BMAPT*, 121). The first part of O.i.41 up to *mi-nu-u*$_2$ belongs to step 1 and is not translated here. Step 3 begins with an instruction to subtract the "watch of the night" from "(the time by which) the night has progressed." The former denotes the duration of the night (D), the latter the time passed between sunset and New Moon (M). The subtraction implies that $M > D$, i.e. New Moon occurs after sunrise. The difference $M - D$ is multiplied by a "displacement" (zi) of unspecified magnitude, and the product is added to the preliminary value $NA_1 = 31$ UŠ that was obtained in step 1. The additional text preserved on Rm4, 748 confirms that O.ii.2–3 cover the alternative case of New Moon before sunrise ($M < D$), as proposed in *BMAPT*, 353. In this case $D - M$ is computed, multiplied by a "displacement" (zi), and the product is subtracted from NA_1 (O.ii.3–4). The new fragment does not resolve the interpretative difficulties of step 3 (*BMAPT*, 121). It is not clear how to reconstruct and interpret R.ii.1, which appears to contain a phrase similar to O.ii.3.

P4.d: NA_1, steps 1 and 2

P4.d (R.i.17–38) contains further exemplary implementations of the procedures for NA_1. The first half of R.i.17 until diri.še = month XII_2 belongs to P4.c and is not translated here. The computations are exemplified for an initial situation with the Moon in 1 Aries and $NA_1 = 21$ UŠ in month XII_2 of an unidentified year. Step 1 (R.i.17–24) concerns the monthly difference to be added to this value for the case when month XII_2 has 30 days (*BMAPT*, 119–120). The text on fragment 5.2 differs in a few minor points from what was previously restored (*BMAPT*, 348–349), without affecting the interpretation (*BMAPT*, 355). In R.i.23 the date and the value of NA_1 for month XII_2, which was mentioned first in R.i.17, are repeated, as opposed to the value of NA_1 and the difference 12;54. Step 2 (R.i.24–31) deals with the case when month XII_2 has 29 days, so that the value of NA_1 computed in step 1 must be reduced (*BMAPT*, 120).

Colophon

The fragment Rm4, 748 adds a bit of text to the colophon, in particular the beginning of the well-known phrase "May whatever I make with my hands go well," which expresses the intention of the scribe to gain beneficial results for himself by pleasing the gods with tablets.

IX Additions and corrections published elsewhere

Table 6 lists editions and investigations of twelve procedure texts for Jupiter that appeared after *BMAPT* (2012). They were either published for the first time or republished to account for substantial new insights about their content. In four procedures the variation of Jupiter's daily motion is modeled as a trapezoidal figure. Eight related procedures deal with the subdivision of Jupiter's synodic cycle in accordance with the scheme dubbed X.S_1. The publications are abbreviated MO2016 = Ossendrijver (2016), etc.

tablet	*BMAPT*	MO2016	MO2017	MO2018	content
BM 34081+	No. 18 P1		Text G		scheme X.S_1
BM 34081+	No. 18 P5	Text C		Text C	trapezoid procedure
BM 34757	No. 38 P4	Text B		Text B	trapezoid procedure
BM 35533			Text B		scheme X.S_1
BM 35915		Text D		Text D	trapezoid procedure
BM 36680	No. 25 P1′		Text C		scheme X.S_1
BM 36801	No. 21 P1		Text E		scheme X.S_1
BM 40054		Text A	Text A		scheme X.S_1
BM 40661	No. 26 P1′		Text H		scheme X.S_1
BM 41043	No. 22 P1		Text D		scheme X.S_1
BM 82824+	No. 40 P1′	Text E		Text E	trapezoid procedure
DT 183	No. 23 P1′		Text F		scheme X.S_1

Table 6: Editions and investigations of Babylonian astronomical procedures that appeared after *BMAPT*.

The fragment BM 47886+47914 (Ossendrijver 2024) contains procedures for various planets including Mercury and Saturn and probably belongs to the same tablet as *BMAPT* No. 95 Three other fragmentary procedure texts, BM 34765 (*BMAPT* No. 45), BM 35078 (*BMAPT* No. 34), and BM 35203 (*BMAPT* No. 98 P1′), are now known to be directly joining fragments of a single tablet inscribed with a compendium of lunar and planetary procedures, as well as synodic tables for the Moon and for Jupiter. The joins affect both tables, but not the procedures. For a new edition of the Jupiter table see Ossendrijver (2025).

X Appendix: Figures

Figure 1: Text A (A 3460): obverse and reverse. Photos by author, courtesy of the Institute for the Study of Ancient Cultures (University of Chicago).

Figure 2: Left: Text B (BM 36950): side X. Right: Text D (BM 48142): obverse and reverse. Photos by author, courtesy of the Trustees of the British Museum.

Figure 3: Text C (BM 41627): obverse and reverse. Photos by author, courtesy of the Trustees of the British Museum.

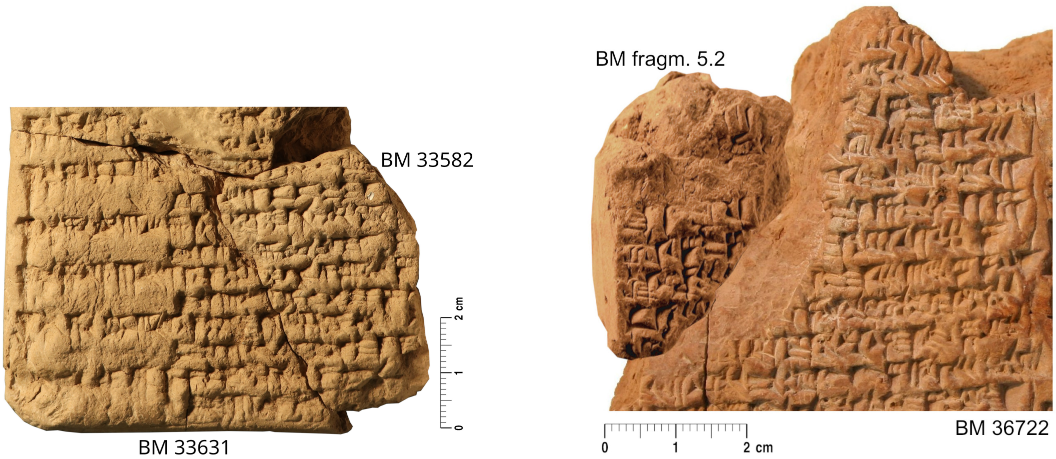

Figure 4: Left: Text E (BM 33582+33631): O12–25. Right: Text H (BM 36722+37205+40082+unnumbered fragment 5.2): R.i.16–26. Photos by author, courtesy of the Trustees of the British Museum.

Figure 5: Text F (BM 33451+47744+47924+49084): O16–R8. Photo by author, courtesy of the Trustees of the British Museum.

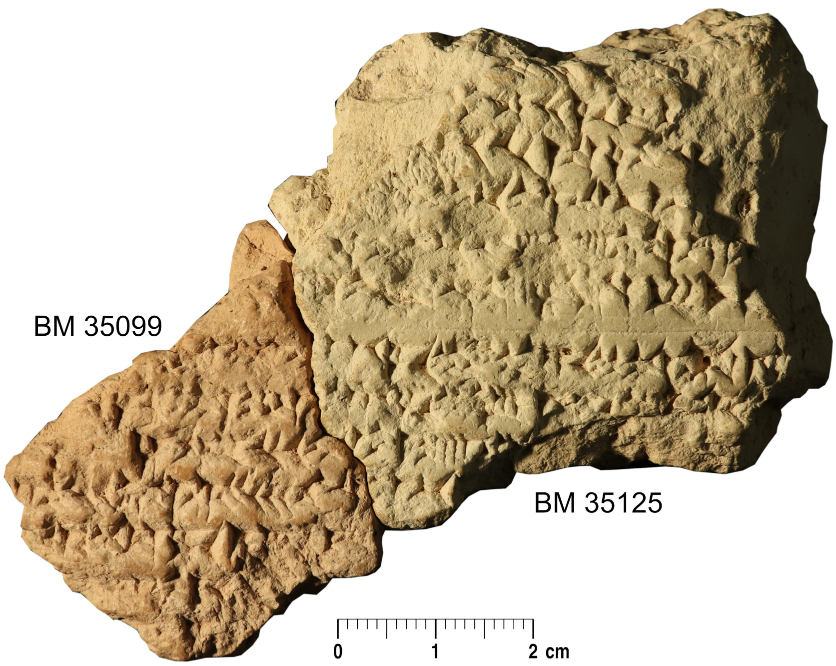

Figure 6: Text G (BM 35099+35125): obverse? Photo by author, courtesy of the Trustees of the British Museum.

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Abbreviations

ACT = Neugebauer (1955)
BMAPT = Ossendrijver (2012)

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Babylonian tablets edited: A 3460, BM 33451+47744+47924+49084, BM 33582+33631, BM 35099+35125, BM 36722+37205+40082+Rm4,748+unnumbered fragment 5.2, BM 36950, BM 41627, BM 48142

Babylonian tablets mentioned: A 3425, BM 34081+, BM 34245+, BM 34757, BM 34765, BM 35078, BM 35203, BM 35399, BM 35533, BM 35915, BM 36436, BM 36680, BM 36723+, BM 36801, BM 40054, BM 40661, BM 41043, BM 46116, BM 47886+47914, BM 82824+, DT 183

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