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Babylonian Observations of Saturn during the Reign of Kandalanu

C. B. F. Walker

BM 76738 + 76813 (AH 83-1-18, 2109 + 2185) (joined by Dr. I. L. Finkel) is a fragment of a tablet containing a collection of observations of the planet Saturn made during the reign of Kandalanu (647–627 B.C.).[1] As such it is the first collection of planetary data since the Venus observations made during the reign of Ammiṣaduqa (1702–1682 B.C., according to Huber's chronology) in the Old Babylonian period. It was presumably excerpted from the Astronomical Diaries, or a similar source. One line includes the comment, *he-pí*, "broken," indicating that at this point the scribe was copying from a broken text. The earliest surviving Astronomical Diary dates from just five years earlier, −651/650 (652/651 B.C.), and includes an observation of the last visibility of Saturn. As in the few surviving Astronomical Diaries dating from before the fourth century B.C., the names given to the various constellations and stars used by the astronomers as reference points for their observations of Saturn differ somewhat from the later standard list of so-called "Normal Stars." However, the general terminology is similar to that of the Diaries.

The registration AH 83-1-18 might at first sight seem to suggest that the tablet came from Sippar (Abu Habba), but as Reade (1986), xxxiv, has pointed out, the collection plainly also included material from Rassam's excavations at Babylon and Borsippa. Not wishing to revive the old discussion about whether there might have been astronomical archives at Sippar, I assume that Babylon or Borsippa is the most likely source of the present tablet.

The text lists the dates of successive first and last visibilities of Saturn in terms of the regnal year, month and day in the lunar calendar. In two cases, lines 7′ and 10′, the date is given only as "at the end of month 4/5." In some cases it is noted that the first or last visibility was not actually observed, and in such cases we must assume that the date was estimated, or as stated in line 23′, *muš-šúḫ*, "calculated." In two cases of first visibility, lines 6′ and 8′, the expression NIM, "high," indicates that the astronomers themselves were aware that the planet was higher in the sky than usual for

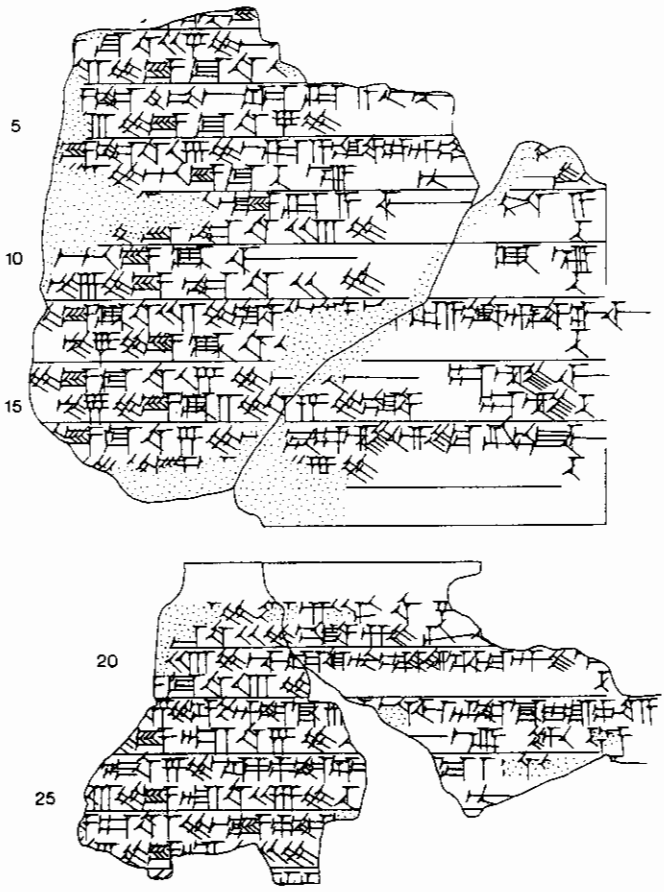

Figure 1
BM 76738 + 76813.

first visibility, implying that under better conditions it would have been visible a day or two earlier.

The location of the planet in the sky is also given in all cases of first visibility except in line 10′ (for which also a precise date was lacking); but for last visibility the location is only given in two cases (lines 15′ and 19′). The planet is nowhere named on the tablet, but the intervals between the various observations (both chronologically and in terms of ecliptic longitude) fit the movements of Saturn and of no other planet. Modern theory calculates the last and first visibility of planets as a pair by reference to the time and location of the conjunction of the planet with the sun that

occurs between last and first visibility. That is also the pairing that we find on the Venus Tablet of Ammiṣaduqa a thousand years earlier, where the concern is with the total length of invisibility. By contrast, on this tablet the Babylonian scribe presents the observations in the sequence of first and last visibility of the planet, each group of two observations being marked off by a ruling with the second line being indented; the conjunction is not yet a point of reference.

The tablet may perhaps be seen as part of the process of collecting and analyzing data whereby the Babylonian astronomers eventually discovered satisfactory means of mathematically describing and predicting planetary movements in terms of time and longitude. Paleographically it seems likely that the tablet was written within a few decades of the date of the latest observation recorded on it. It is of course obvious from the circumstance that the tablet is incomplete, that the chronological range of observations being examined was wider than the reign of Kandalanu.

The name of the planet Saturn is not given on the tablet, and the name of Kandalanu is to be restored from only a few traces in the first line. It is, however, certain that we are dealing with Saturn and Kandalanu. Saturn is the slowest moving of the visible planets, and only Saturn would move the distances indicated between successive first visibilities. A complete cycle of Saturn phenomena in relation to the stars takes 59 years. But when that cycle has to be fitted to the lunar calendar of 29 or 30 days then identical cycles recur at intervals of rather more than 17 centuries. Thus there is no difficulty in determining the date of the present text.

TRANSLITERATION

1′ [MU 1-KAM *kan-d*]*a-*⌜*la-nu* ITU⌝-[x U_4 x-KAM ŠÚ]

2′ [MU 1-KAM IT]U-ŠU U_4 24-KAM *ina* I[GI ... ALLA ... IGI]

3′ [M]U 2-KAM ITU-ŠU U_4 10+[x ŠÚ]

4′ [MU 2-KAM IT]U-NE *ḫe-pí ina* SAG ⌜UR-A IGI NU⌝ [ŠEŠ? ŠE/KIN DIRI]

5′ [M]U 3-KAM ITU-ŠU U_4 7-KAM [ŠÚ]

6′ [MU 3-KAM] ITU-NE U_4 16-KAM *ina* UR-A EGIR MUL-LUGAL [IGI] NI[M?-A]

7′ [MU] ⌜4⌝-KAM *ina* TIL ITU-ŠU ŠÚ DIR NU ŠEŠ

8′ [MU 4-KAM ITU-KIN?] ⌜U_4⌝ [x]-⌜KAM⌝ *ina* $MURUB_4$ UR-A IGI NIM-A

9′ [MU 5]-ᵀKAM ITU-NEᵀ U_4 23-KAM ŠÚ

10′ [MU 5-KAM] ᵀ*ina* TILᵀ ITU-KIN IGI KIN DIRI

11′ MU 6-KAM ITU-NE U_4 20-KAM ŠÚ

12′ [MU 6-KA]M ITU-KIN U_4 22-KAM EGIR ᵀGÌR EGIR *ša*? URᵀ-A EGIR AN.GÚ.ME.MAR IGI

13′ MU 7-KAM ITU-KIN U_4 10+[x-KAM] ŠÚ

14′ [MU 7]-KAM ITU-DU_6 U_4 15-KAM ᵀ*ina* IGIᵀ AB.SÍN IGI

15′ MU 8-KAM ITU-KIN 2-KAM U_4 5-KAM EGIR AB.SÍN ŠÚ

16′ [MU 8-KA]M ITU-DU_6 U_4 5-KAM *ina* D[AL]-BAN AB.SÍN *u zi-ba-ni-tum* IGI

17′ [M]U ᵀ9-KAM ITU-KINᵀ [U_4] ᵀ20ᵀ+ᵀ7/8ᵀ-KAM ŠÚ

Reverse

18′ [MU 9-KAM ITU-APIN U_4 x]+1-KAM ᵀŠÀ?ᵀᵀ*zi*ᵀ-*bānī*(DÙ)-*tú* ᵀ*šá*ᵀ [... IGI ...]

19′ [MU 10-KAM ITU]-ᵀDU_6ᵀ U_4 20-KAM EGIR *zi-bānī*(DÙ)-*t*[*ú* ŠÚ]

20′ [MU 10-KAM ITU-APIN U_4] 23-KAM *ina* IGI SAG-KI GÍR-TAB Á IM-SI IGI *ba-ìl* ŠE D[IRI?]

21′ [MU 11-KAM IT]U-DU_6 U_4 13-KAM ŠÚ

22′ [MU 11-KAM ITU-APIN U_4] ᵀ15ᵀ-KAM *e-lat* $^{d}li_9$-si_4 ᵀ$6\frac{1}{2}$? UŠᵀ IGI *ana* $^{d}li_9$-si_4 *i-si pa-na-a*

23′ [MU 12-KA]M ITU-APIN U_4 5-KAM ᵀŠÚᵀᵀ*ina*ᵀ DIR *muš*-ᵀ*šúḫ*ᵀ

24′ [MU 12-KAM ITU]-GAN U_4 5-KAM *ina* SAG PA-BIL-SA[G IGI?] x *ma* 1 ᵀUŠ?ᵀ x [x] x

25′ [MU] 13-KAM ITU-APIN U_4 26-KAM ŠÚ [DIR?] NU [ŠEŠ]

26′ [MU 13-KAM IT]U-AB U_4 1-KAM *ina* $MURUB_4$ PA-BIL-S[AG IGI ...]

27′ [M]U ᵀ14-KAMᵀ ITU-ᵀAPIN U_4 20ᵀ-KAM [ŠÚ ...]

28′ [MU 14-KAM ITU-GAN U_4] ᵀ20ᵀ+[?-KAM x] x ᵀMUL?-xᵀ [... IGI ...]

Translation

1′ [Year 1 of Kand]alanu, ᵀmonthᵀ [..., day ..., last appearance.]

2′ [Year 1, mont]h 4, day 24, in fr[ont of ... the Crab, first appearance.]

3′ [Ye]ar 2, month 4, day 10+[x, ..., last appearance.]

4′ [Year 2, mon]th 5, broken, in the head of the Lion, first appearance; not [observed?.]

5′ [Ye]ar 3, month 4, day 7, [last appearance.]

6′ [Year 3], month 5, day 16, in the Lion behind the King (= α Leonis), [first appearance]; ⌜high⌝.

7′ [Year] ⌜4⌝, at the end of month 4, last appearance; (because of) cloud not observed.

8′ [Year 4, month 6?], day [x], in the middle of the Lion, first appearance; high.

9′ [Year 5], month 5, day 23, last appearance.

10′ [Year 5], at the end of month 6, first appearance; intercalary Ululu.

11′ Year 6, month 5, day 20, last appearance.

12′ [Year 6], month 6, day 22, behind ⌜the rear foot of⌝ the Lion (= β Virginis), behind AN.GÚ.ME.MAR, first appearance.

13′ Year 7, month 6, day 10+[x], last appearance.

14′ [Year 7], month 7, day 15, ⌜in front of⌝ the Furrow (α+ Virginis), first appearance.

15′ Year 8, month 6, day 5, behind the Furrow (α+ Virginis), last appearance.

16′ [Year 8], month 7, day 5, ⌜between⌝ the Furrow (α+ Virginis) and the Balance (Libra), first appearance.

17′ [Year] ⌜9, month 6⌝, [day] ⌜27/28?⌝, last appearance.

Reverse

18′ [Year 9, month 8, day x]+1, ⌜within?⌝ the Balance,... [..., first appearance].

19′ Year 10, month] ⌜7⌝, day 20, behind the Balance, [last appearance].

20′ [Year 10, month 8, day] 23, in front of the Forehead of the Scorpion, on the north side, first appearance; it was bright; intercalary Addaru.

21′ [Year 11, month] 7, day 13, last appearance.

22′ [Year 11, month 8, day] ⌜15⌝, above Lisi (= α Scorpii) ⌜6½ degrees⌝, first appearance; with reference to Lisi a little in front(?).

23′ [Year 12], month 8, day 5, last appearance; ⌜because of⌝ cloud computed.

24′ [Year 12, month] 9, day 5, at the beginning of Pabilsag (= Sagittarius + part of Ophiuchus), [first appearance?]; ... 1 degree? ...

25′ [Year] 13, month 8, day 26, last appearance; [cloud?], not [observed?].

26′ [Year 13, month] 10, day 1, in the middle of Pabilsag, [first appearance; ...]

27′ [Year] ⌜14⌝, month ⌜8⌝, ⌜day 20⌝, [last appearance; ...]

28′ [Year 14, month 9, day] ⌜20⌝[+ ?, ...] ... [..., first appearance; ...]

a	b	c	d
Conjunction	Long.		LE/FM
−646/6/28	89°	−15	e6/13
		+19	m7/17
−645/7/13	102°	−15	e6/28
		+18	m7/31
−644/7/26	116°	−16	e7/10
		+16	m8/11
−643/8/8	128°	−16	e7/23
		+16	m8/24
−642/8/21	141°	−16	e8/5
		+15	m9/5
−641/9/3	153°	−17	e8/17
		+15	m9/18
−640/9/15	166°	−17	e8/29
		+14	m9/29
−639/9/27	178°	−17	e9/10
		+13	m10/10
−638/10/8	189°	−17	e9/21
		+13	m10/21
−637/10/20	200°	−17	e10/3
		+13	m11/2
−636/10/30	211°	−17	e10/13
		+14	m11/13
−635/11/10	222°	−16	e10/25
		+14	m11/24
−634/11/21	233°	−16	e11/5
		+15	m12/6
−633/12/2	244°	−15	e11/17
		+16	m12/18

e	f	g	h	i
NM	Day	Bab. Y/M/D	−	+
e5/25	20	[1/.../...]	?	
e6/24	23	[1]/4/24		+1
6/13	16	2/4/10+[x]	?	
7/13	18	2/5/*ḫe-pī*		?
7/1	10	3/4/7	−3	
7/31	11	3/5/16 high		+5
7/20	4	4/TIL ITU-ŠU	?	
8/19	5	[4/6?/...] high		?
7/10	27	[5]/5/23	−4	
8/8	28	[5]/TIL ITU-KIN		?
7/28	21	6/5/20	−1	
8/27	22	[6]/6/22		0
8/15	15	7/6/10+[?]	?	
9/14	15	[7]/7/15		0
9/3	8	8/6/5	−3	
10/3	7	[8]/7/5**		−2
8/23	30	9/6/20 + 7/8	−2?	
9/22	29			
or 10/22		[9/8]/[x]+⌜1⌝		+2?
9/11	23	10/7/20	−3	
10/11	22	[10/8]/23		+1
9/29	15	[11]/7/13	−2	
10/29	15	[11/8]/15		0
10/18	8	[12]/8/5	−3	
11/17	7	[12]/9/5**		−2
10/8	29	13/8/26	−3	
11/6	30			
or 12/6		[13]/10/1		+1
10/27	22	14/8/⌜20⌝	−2	
11/25	23	[14/9]/⌜20⌝+[x]		?

The Visibility of Saturn

A procedure for establishing the dates and place in the ecliptic of first and last visibility of Saturn is given by Schoch (1928), 109 (with pl. 14); his Table C (Conjunction) for the time intervals between conjunction and first and last visibility has been revised by van der Waerden (1943). The procedure can now be simplified by the use of the published tables of Hunger and Dvorak (1981). For the years −647 to −633 the table on pp. 66–67 gives:

(a) the date (year, month, day) of conjunction between Saturn and the sun,

(b) the approximate longitude of conjunction (to the nearest degree),

(c) the number of days before (−) and after (+) conjunction at which last evening and first morning visibility may be expected for a conjunction at that longitude,

(d) the resulting date in the Julian calendar (month, day) for theoretical last evening (LE) or first morning (FM) visibility (by modern, not Babylonian, calculations),

(e) the date (month, day) in the Julian calendar of the preceding new moon (NM),

(f) the day in the Babylonian lunar month on which last/first visibility may be expected [N.B. Babylonian observations of first morning visibility are made on the Babylonian day, which began on the previous evening],

(g) the Babylonian date (year/month/day, using the lunar month) on which last/first visibility is recorded,

(h) comparison of (g) with (f) for last visibility,

(i) comparison of (g) with (f) for first visibility.

(a) and (b) are derived by interpolation from the tables of Hunger and Dvorak (1981); (c) is taken from van der Waerden (1943); (d) is taken from a computer program by P. Huber, but an approximate date can be obtained by taking the dates of "new moon" given in Goldstine (1973), and adding 2 or 3 days.

On the assumptions that the text is not corrupt and that the modern theory is good for ancient Babylonian observations (i.e., that the Babylonians would not have seen Saturn after the calculated date for last visibility, nor before the calculated date for first visibility), where the figure in column (c) is negative, the day number in column (g) should be equal to or lower than the figure in column (f), and this should result in a 0 or a minus quantity in column (h); where the figure in column (c) is positive, the day number in column (g) should be not less than the figure in column (f) −1 (this allows for the possibility of the Babylonian lunar month starting one day later than calculated), and this should result in a figure of −1 or higher in column (i). One must also make the appropriate adjust-

ments at the month boundaries. In practice all the recorded observations fit this pattern well, except for the two cases marked **, where the Babylonians appear to have seen the planet for the first time at least one day earlier than expected (according to van der Waerden's visibility tables) even allowing for the possibility that they had previously seen the new moon one day late. These two cases are perhaps to be explained as scribal errors, the miscopying of 5 for 8.

THE BABYLONIAN CALENDAR

The Babylonian calendar was luni-solar with an additional "intercalary" month being added on average 7 times in 19 years to bring the lunar and solar cycles into line. In the seventh century B.C. the later "Metonic" pattern of regular intercalations was not yet in place and it is a matter of interest to establish in which years the intercalary months were inserted.

The synodic period of Saturn is 378.09 days. Hence phenomena recur about 24 days later in the Babylonian calendar than in the previous year (Schoch [1928], 109). In consequence the present text allows us to establish the approximate, or sometimes the precise, position of intercalary months in the years covered by this text (647–634 B.C.). The textual indications, line 10′ (MU 5-KAM ... KIN DIRI), line 15′ (MU 8-KAM ITU-KIN 2-KAM), line 20′ (MU 10-KAM ... ŠE D[IRI]), fit the astronomical requirements. The intercalary months in years 5 and 10 are also confirmed by contemporary economic texts (Brinkman and Kennedy [1983], 40–42). Additionally an intercalary month (Ululu or Addaru) is required in year 2, and either an intercalary Addaru in year 13 or intercalary Ululu in year 14. If we assume, on the basis of the record which the scribe gives of intercalary months in years 5, 8, and 10, that he was deliberately recording these in order to assess the synodic period of Saturn, then we may also note that there is room to restore KIN/ŠE DIRI at the end of line 4′ (for year 2), and to restore either ŠE DIRI at the end of line 26′ (for year 13) or KIN DIRI at the end of line 27′ (for year 14).

The exact dates that can be derived from the present text allow us to give the following table for years 2–14 of Kandalanu, using dates for first lunar visibility computed by P. Huber, and following the same principles as the tables in Parker and Dubberstein (1956); that is that the Babylonian day is equated with the Julian day that began at the midnight following the evening beginning of the Babylonian day (this is in contrast with the previous table of Saturn visibility). The last part of year 2, the end of year 13, and the first part of year 14 are italicized because of the uncertainty over whether the relevant intercalary months were Ululu or Addaru.

Kandalanu

YR	B.C.	Nis	Aia	Sim	Duz	Abu	Ulu
2	646	3/18	4/17	5/16	6/14	7/14	8/12
3	645	4/5	5/5	6/3	7/2	8/1	8/30
4	644	3/25	4/24	5/23	6/22	7/21	8/20
5	643	3/14	4/13	5/12	6/11	7/11	8/9
6	642	4/2	5/1	5/31	6/30	7/29	8/28
7	641	3/21	4/20	5/19	6/18	7/17	8/16
8	640	3/11	4/9	5/9	6/7	7/7	8/5
9	639	3/30	4/28	5/28	6/26	7/25	8/24
10	638	3/20	4/18	5/17	6/16	7/15	8/13
11	637	4/7	5/6	6/4	7/4	8/2	9/1
12	636	3/27	4/25	5/25	6/23	7/23	8/21
13	635	3/16	4/15	5/14	6/13	7/12	8/11
14	634	*4/3*	*5/3*	*6/2*	*7/2*	*7/31*	*8/30*

We are getting close to the point at which we could extend Parker and Dubberstein's tables for Babylonian chronology back in a continuous series from the reign of Nabopolassar to the beginning of the reign of Kandalanu. An intercalary Ululu is attested for Kandalanu's 19th year (Brinkman and Kennedy [1992], 47–48). It remains to identify the intercalary month expected in Kandalanu's 16th year, and to identify the missing intercalary month between Kandalanu year 19 and Nabopolassar year 2. This may be the intercalary Addar in Nabopolassar's first year recorded by Kennedy (1986), 179, but the reading of the date is disputed.

THE BABYLONIAN STARS AND CONSTELLATIONS

The following list gives those Babylonian observations in which the planet's approximate longitude is indicated, the Julian date of calculated first/last visibility, the planet's ecliptic longitude and latitude at that date (derived by interpolation from the tables of Hunger and Dvorak [1981]), and the ecliptic longitude and latitude of the nearest relevant star(s); all figures are rounded to one decimal place. Wherever possible this corresponds to a star from the list of Normal Stars. For a list of Normal Stars and their approximate ecliptic coordinates in −600 see Sachs and Hunger (1988), 17–19.

2′ [MU 1-KAM IT]U-ŠU U_4 24-KAM *ina* I[GI ... ALLA ... IGI]
−646/7/17 91.1°, 0.0° *θ* Cnc, 89.0°, −0.7°

Ulu 2	Tas	Ara	Kis	Teb	Sha	Add	Add 2
	9/10	*10/10*	*11/8*	*12/8*	*1/7*	*2/6*	*3/6*
	9/29	10/28	11/26	12/26	1/25	2/23	
	9/18	10/18	11/16	12/16	1/14	2/13	
9/8	10/7	11/6	12/5	1/4	2/2	3/4	
	9/27	10/26	11/25	12/24	1/23	2/21	
	9/15	10/14	11/13	12/13	1/11	2/10	
9/4	10/3	11/2	12/2	1/1	1/30	2/1	
	9/23	10/22	11/21	12/21	1/20	2/18	
	9/12	10/11	11/10	12/10	1/9	2/7	3/8
	9/30	10/29	11/28	12/28	1/26	2/25	
	9/20	10/19	11/17	12/17	1/16	2/14	
	9/9	10/9	11/7	12/6	1/5	2/3	*3/5*
	9/28	10/28	11/26	12/26	1/24	2/22	

4′ [MU 2-KAM IT]U-NE *ḫe-pí ina* SAG ⌜UR-A IGI NU⌝ [ŠEŠ?]
−645/7/31 104.6°, 0.5° *ε* Leo, 104.0°, 9.8°

6′ [MU 3-KAM] ITU-NE U_4 16-KAM *ina* UR-A EGIR MUL-LUGAL [IGI] NI[M?-A]
−644/8/11 117.6°, 1.0° *α* Leo, 113.1°, 0.6°

8′ [MU 4-KAM ITU-KIN?] ⌜U_4⌝ [x]-⌜KAM⌝ *ina* MURUB$_4$ UR-A IGI NIM-A
−643/8/24 130.5°, 1.5° *ρ* Leo, 119.7°, 0.3°
θ Leo, 126.7°, 9.9°
χ Leo, 127.8°, 1.6°

12′ [MU 6-KA]M ITU-KIN U_4 22-KAM EGIR ⌜GÌR EGIR *ša*? UR⌝-A EGIR AN.GÚ.ME.MAR IGI
−641/9/18 155.4°, 2.1° *β* Vir, 140.4°, 1.1°
η Vir, 147.9°, 2.3°
γ Vir, 153.5°, 3.0°
Jupiter, 151.5°, 1.12°

14′ [MU 7]-KAM ITU-DU6 U_4 15-KAM ⌜*ina* IGI⌝ AB.SÍN IGI
−640/9/29 167.4°, 2.3° *α* Vir, 167.2°, −1.8°

15′ MU 8-KAM ITU-KIN 2-KAM U_4 5-KAM EGIR AB.SÍN ŠÚ
−639/9/10 175.5°, 2.3° *α* Vir, 167.2°, −1.8°

16′ [MU 8-KA]M ITU-DU6 U_4 5-KAM *ina* D[AL]-BAN AB.SÍN *u zi-ba-ni-tum* IGI
−639/10/10 179.0°, 2.3° *α* Vir 167.2°, −1.8°
α Lib 188.4, 0.6°

18′ [MU 9-KAM ITU-APIN U_4 x]+1-KAM ⌜ŠÀ?⌝ ⌜*zi*⌝-*bānī*(DÙ)-*tú* ⌜*šá*⌝ [... IGI ...]
−638/10/21 190.4°, 2.3° α Lib 188.4°, 0.6°
β Lib, 192.8°, 8.7°

19′ [MU 10-KAM ITU]-⌜DU6⌝ U_4 20-KAM EGIR *zi-bānī*(DÙ)-*t*[*ú* ŠÚ]
−637/10/3 198.2°, 2.2° β Lib, 192.8°, 8.7°

20′ [MU 10-KAM ITU-APIN U_4] 23-KAM *ina* IGI SAG-KI GÍR-TAB Á IM-SI IGI *ba-ìl* ŠE D[IRI?]
−637/11/2 201.7°, 2.2° δ Sco, 206.0°, −1.8°

22′ [MU 11-KAM ITU-APIN U_4] ⌜15⌝-KAM *e-lat* $^{d}li_9$-si_4 ⌜6½? UŠ⌝ IGI *ana* $^{d}li_9$-si_4 *i-ṣi pa-na-a*
−636/11/13 212.9°, 2.0° α Sco. 213.2°, −4.4°

24′ [MU 12-KAM ITU]-GAN U_4 5-KAM *ina* SAG PA-BIL-SA[G IGI?] x *ma* 1 ⌜UŠ?⌝ x [x] x
−635/11/24 224.0°, 1.7° β Oph, 224.8°, −1.7°

26′ [MU 13-KAM IT]U-AB U_4 1-KAM *ina* $MURUB_4$ PA-BIL-S[AG IGI ...]
−634/12/6 235.2°, 1.4° μ Sgr, 236.7°, 2.4°

28′ [MU 14-KAM ITU-GAN U_4] ⌜20⌝+[?-KAM x] x ⌜MUL?-x⌝ [... IGI ...]
−633/12/18 246.5°, 1.0° σ Sgr, 245.8°, −3.4°
ν Sgr, 245.9°, 0.2°
ξ Sgr, 246.9°, 1.8°

STAR IDENTIFICATIONS

2′. The broken reference is probably to the constellation Cancer, but note that Saturn is already to the west of the first Normal Star in Cancer, θ Cnc. This star is first attested written as MUL IGI *ša* ALLA *ša* ULÚ in Diaries of the 4th century B.C.

4′. SAG UR-A: in the Diaries from −380 onward SAG UR-A designates ε Leonis.

6′. Interpretation of MUL-LUGAL as α Leo raises no problems.

8′. ina $MURUB_4$ UR-A: of the preceding Normal Stars in Leo ρ is described by the Babylonians as the small star 4 cubits behind Regulus, and θ is described as the Lion's flank. The nearest bright star to Saturn seems to be χ Leo, but in all probability *ina* $MURUB_4$ UR-A simply means within the constellation Leo.

12′. EGIR ⌜GÌR EGIR *ša*? UR⌝-A EGIR AN.GÚ.ME.MAR: in the standard list of Normal Stars it is β Virginis, which is known as GÌR *ár šá* A (so

already in the Diary for −567, written GÌR *ár šá* UR-A). In fact the calculated location of the planet at first visibility is considerably to the east of *β* Virginis, and just behind *γ* Virginis. But *γ* Virginis is known in the Diaries as DELE *šá* IGI ABSIN. Why should our text refer at all to GÌR EGIR *ša* UR-A, and what is AN.GÚ.ME.MAR? H. Hunger pointed out to me some time ago that in the Diary for −567 GÌR *ár šá* UR-A (*β* Virginis) is written by mistake for *γ* Virginis, and wondered whether the same mistake had happened here. He also pointed out that on this occasion Jupiter is also in the vicinity, and wondered if there could be some way of bringing together AN.GÚ.ME.MAR and the traditional writing of Jupiter as ^{d}SAG-ME-GAR. It seems problematic, but I have no better solution.

14′. AB.SÍN: "the Furrow." In later Babylonian astronomical texts AB.SÍN and ABSIN (KI.AŠ.AŠ) are used to designate the whole zodiac sign Virgo. Since *γ* Vir, which Saturn passed a year before, is described as DELE *šá* IGI ABSIN, it seems that AB.SÍN here must refer to *α* Virginis (Spica); but note that Saturn has in fact just passed it. The reference to AB.SÍN in the next line raises no such problems.

16′. The description of Saturn's position here raises no problems.

18′. ⌜ŠÀ?⌝⌜*zi*⌝-*bānī*(DÙ)-*tú* ⌜*šá*⌝ [...]: the reading ⌜ŠÀ⌝ seems assured from the traces, and makes sense astronomically, but the commoner expression in this context would be ina MURUB$_4$; cf. lines 8′ and 26′. The following *šá* is suggestive of the Normal Star names RÍN *šá* ULÚ and RÍN *šá* SI, but it is not obvious that either of these is appropriate here.

19′. The description of Saturn's position here raises no problems.

20′. SAG-KI GÍR-TAB: this expression is not attested elsewhere. In the Diaries for −384, −375, −373 and −372 SAG GÍR-TAB = the head of the Scorpion, and in Diaries from −382 onwards MÚL *e šá* SAG GÍR-TAB = *β* Scorpii.

22′. ^{d}*li*$_9$-*si*$_4$: the Diaries for −651 and −567 use the abbreviation SI$_4$ for *α* Scorpii. ⌜6$\frac{1}{2}$? UŠ⌝: the use of the UŠ, normally translated "time-degree" in ACT, as a unit of angular measurement in observations (rather than calculations) here and apparently in line 24′, is of considerable interest. The normal units of measured observation in Late Babylonian astronomical texts are the cubit (KÙŠ) and the finger (SI). The only other evidence for this use of UŠ is given by Pingree (1993), 271, with reference to observing the movement of the rising-point of Venus on the horizon. *ana* ^{d}*li*$_9$-*si*$_4$ *i-ṣi pa-na-a*: cf. the regular use of *i-ṣi* in the Diaries in descriptions of the position of the moon and planets relative to fixed stars.

24′. *ina* SAG PA-BIL-SA[G IGI?] x *ma* 1 ⌜UŠ?⌝ x [x] x: the constellation Sagittarius falls in that part of the zodiac in which, for no reason apparent to us, there are large gaps in the list of Normal Stars; thus there is no later

terminology comparable with *ina* SAG/MURUB$_4$ PA-BIL-SAG here and in line 26′. Calculation shows that Saturn will have become visible in the vicinity of θ Ophiuchi; the earliest references to this Normal Star in the Diaries give its name as MÚL KUR *šá* KIR$_4$ *šil* PA (diary for −381) or MÚL KUR *šá šil-taḫ* PA (diary for −380(B)). The translation of SAG as "beginning" assumes that the constellation was visualized approximately as in the star catalogue in Ptolemy's *Almagest*. The translation "head" would assume a significantly different configuration, and would also be at variance with the idea that θ Ophiuchus was part of Pabilsag's arrow.

26′. *ina* MURUB$_4$ PA-BIL-S[AG]: I give the co-ordinates of θ Sagittarii for reference, but the expression probably simply means in the middle of Pabilsag/Sagittarius.

28′. [x] x ⌜MUL?-x⌝ [...]: given the approximate ecliptic longitude of the planet at first visibility, it is possible that we have here a reference to the star group in Sagittarius known from the Normal Star Almanacs as MUL-4-ÁM *šá* PA *šá ár*. This star group has been discussed recently by Roughton and Canzoneri (1992).

ADDITIONAL COMMENTS

1′. The name Kandalanu is restored in the light of astronomical considerations, but the position in the line of the sign ITU already indicated that it was preceded by a royal name.

4′. *ḫe-pí*: broken: this would appear to indicate that in the original diary from which this entry is taken the day number is lost; however the fact that the planet's reappearance was apparently not observed is at variance with the idea that the original diary may have contained the date of an observation. Cf. also lines 23′ and 25′. It is preferable to assume that in these cases the date of theoretical first or last visibility was deduced from the planet's position when first or last actually seen (cf. lines 6′ and 8′, NIM, "high"). NU [ŠEŠ]: restored after line 7′; but note that unlike line 7′ (and 25′?) there is no reference to clouds here.

6′ & 8′. NIM, high: this term indicates that when first observed the planet was higher above the horizon than normal for first visibility, leading to the conclusion that theoretical first visibility had occurred a day or two earlier, but had not been observed. See Huber (1982), 12–13.

10′. *ina* TIL ITU-KIN: the omission of the day of the month suggests either that the (theoretical) first visibility was not observed (cf. line 7′), or that the day was not recorded in the sources available to the compiler of the present text. Note that the use of the expression *ina* TIL ITU is common in the summaries of planetary positions in the Diaries.

14′. In the Diaries from −440 onward α Virginis is SA_4 *šá* ABSIN, "the bright star of ABSIN." The Sumerian ABSIN means "furrow," and the constellation name is generally so translated. Note, however, that Sachs (1952), 146 n. 3, and Thureau-Dangin (1938), 36 n. 2, preferred the translation "Barley-stalk" (French épi) for AB.SÍN. The picture of the lady holding an ear of barley (Spica?), which appears on AO 6448 (Weidner [1967], pl. 10), may reflect the later influence of Greek ideas.

16′. DAL.BAN = *birīt*; elsewhere normally written DAL.BA.(AN).NA.

17′. Note the late form of 9 in MU 9-KAM; hence the day number here can only be 27 or 28.

18′. Astronomically it seems quite probable that one should read simply [... ITU-APIN U_4] 1-KAM; see above, on the dates of first and last visibility of Saturn. A restoration [... ITU-DU_6 2]⌜8⌝-KAM would only be possible if the planet had been seen on the first possible day allowed by van der Waerden's visibility table.

20′. ŠE D[IRI]: the restoration takes into account the astronomical requirement for an intercalary month at the end of Kandalanu year 10 or in the middle of year 11, and is supported by contemporary economic texts; see below.

22′. [... U_4] 15-KAM: the reading 15, rather than ⌜2⌝5, is dictated by astronomical considerations; see above.

23′. *ina* DIR: the Diaries normally say only DIR.

muš-⌜*šúh*⌝, "measured": cf. P. J. Huber, Babylonian eclipse observations, 750 B.C. to 0 (privately circulated typescript, Harvard University, 1973), 6.

25′. Cf. the comment on line 4′.

NOTE

1. The text has been discussed or alluded to previously in Walker (1983), 20–21, Brinkman (1984), 105 n. 521, 118 n. 576, Brinkman (1991), 66 n. 472, and Sachs and Hunger (1988), 13.

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