ASTRAL SCIENCES IN MESOPOTAMIA

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CHAPTER TWO

ASTRONOMY

A. THE EARLY PERIOD

1. Astronomy in Enūma Anu Enlil

1.1. The Venus Tablet of Ammiṣaduqa

This text constitutes Tablet 63 of *Enūma Anu Enlil*, which is the last Tablet of the section on Venus. Twenty sources were available for the edition by Reiner and Pingree [1975], indicated by the letters from A to V (omitting I and S); but it was suggested that A (K 2321 + 3032) and M (K 3105) may be parts of the same Neo-Babylonian copy; F (BM 37010) and H (BM 36758 + 37496) of another Neo-Babylonian copy; L (K 12344 + 12758), P (K 7072), and Q (Sm 174) of a third; and T (K 5963 + Rm. 134) and U (K 12186) of a fourth. If all these associations were correct, the number of independent sources would be reduced to fifteen. Walker [1984] further added to the combination of L, P, and Q both G (Rm 2, 531) and R (K 7090) to form a single, but incomplete, Late Assyrian tablet; and he added to F and H sources J (BM 36395) and O (BM 37121 + 37432). These associations, assuming that they are correct, reduce the number of known independent sources to eleven. Of these A (+ M) was copied by Nergal-uballiṭ, who identifies it as Tablet 63; and B (W 1924.802), which was found at Kish in 1924, was copied from a tablet written at Babylon by Nergal-ēpuš while Sargon was king of Assyria, between -720 and -704. B is the oldest datable copy of Tablet 63 that we have. According to Walker the latest sources—E (BM 41498), K (BM 34227 + 42033), and N (BM 41688), which are Late-Babylonian (i.e., early sixth century B.C.)—represent a late edition in which additional material was inserted between sections III and IV.

The four sections of the Tablet are constituted as follows:

Section I: omens 1 - 21, where each omen (except omen 10, which is a dated report of a disappearance of Venus in the East) consists of four parts: the date (month and day) of a disappearance of Venus in the East or the West; a statement expressed in (months and) days of its period of invisibility; the date (month and day) of an appearance in the West or the East; and an apodosis.

Section II: omens 22 - 33, which have the structure: the date (month and day) of an appearance of Venus in the East or the West; an apodosis; a statement that it remains present in the East or the West until a given date (month and day, eight months and four days later); the date (month and day, one day later than the preceding date) of its disappearance; the period of its invisibility (always three months at superior conjunction, 7 days at inferior conjunction); the date (month and day) of its appearance in the West or the East; and a second apodosis.

Section III: omens 34 - 37, structured like those in section I.

Section IV: omens 38 - 59, in which omens 1 - 21 and 34 - 37 (with the omission of omens 10, 11, and 34) are rearranged in the order of the dates of the first phenomenon (disappearance) in each.

In source B section IV is omitted, but section III is followed by a subscript, omen 60 (which is a correction of omen 17), and another subscript; the same subscript, omen 60, and second subscript, followed by a colophon, are the sole surviving lines of source R (K 7090). Instead of omen 17 section III contains, in omen 50, a copy of omen 60. The correction of omen 17 may have been made independently by the compiler of section III, or he may have known the source of B and R.

This introduces the problem of the sources of the data in Tablet 63. This was discussed at length in Reiner-Pingree [1975] 21-25. Their conclusions may be summarized as follows:

Sections I and III constitute a single source, designated β, into which section II was inserted sometime before the reign of Sargon II. Section IV had a source, designated γ, that rearranged the same omens with the exception of omen 10 (which is a report), omen 17 (for which γ has the same correction as does omen 60), omen 34 (in which uniquely the first phenomenon occurred in an intercalary month), and omen 11 (which contains an egregious error). It is noted that omen 21, the last omen in section I, is in fact a corrected form of omen 11; and that omen 21 appears in γ as omen 59. These facts lead to the conclusion that there was a source α from which β and γ were independently derived. It may not, therefore, be without significance that B omits γ and that T+U contains only γ.

The common source of β and γ, designated α, had three sources for the omens found in sections I, III, and IV. One contained in almost completely correct form omens 1 to 10 in β, which cover the first eight years of the reign of Ammiṣaduqa and is the main check (not determinant) on the chronology of the First Dynasty of Babylon provided by this text; the one error in β (a month VII for a month IV in omen 4) is not present in γ (omen 43, which had month IV). The second group, omens 11 to 21 in β, represents the second eight-year period in the reign of Ammiṣaduqa, with omen 21 being a correction of omen 11. But the text of β is extremely corrupt (about half of

its entries are astronomically impossible if they are regarded as a continuation of omens 1 to 10). Some of the errors in this part were already present in the α text because they are also found in γ. These omens do not preserve trustworthy data, and necessitate the rejection of data that is not compatible with any given chronology. Such rejection of data that contradicts a theory obviously undermines the persuasiveness of the theory, which cannot explain the given data. Even more dubious are the data in omens 34 to 37 of β. Those who wish to see this group as a continuation of omens 1 to 21 of β must assume that the entries for year 18 of Ammişaduqa were missing in α and must also deal with the fact that there are astronomical and textual problems with three of the four omens. It is likely that these omens came from some other source than the records of the reign of Ammişaduqa.

But α cannot represent the form in which the observations of appearances and disappearances of Venus were originally recorded. This is clear from the fact that the intervals of invisibility are computed; their computation is established by the fact that the months in these intervals always contain 30 days. Thus, in omen 3, VI 23 + 20 days gives VII 13; in omen 6, VIII 28 + 3 days gives IX 1; in omen 8, V 21 + 2 months 11 days gives VIII 2; in omen 9, IV 25 + 7 days gives V 2; in omen 13, VI 26 + 11 days gives VI_2 7; and in omen 18, V 20 + 2 months 15 days gives VIII 5. And, when the dates in an omen are wrong, the interval is computed from the erroneous values. Moreover, it seems likely that section II (omens 22 to 33) was a part of α, and, as we shall see, this section was certainly composed long after the original observations. The form of the reports that are the basis of the omens in α was presumably that of omen 10: In Addaru the 25th day Venus set in the East: Year of the Golden Throne. Fortunately we know that the Year of the Golden Throne was year 8 of the reign of Ammişaduqa.

Table of Data in β

Year	Omen	Last visibility	Interval of invisibility	First visibility
[1]	1	Ω XI 15 (B) Ω (A)	3d (AB)	Γ XI 18 (B) Γ (A)
[2]	2	Σ VIII 11 (B) Σ (A)	2m 7d (B) 2m 8d (A)	Ξ X 19 (B) Ξ (A)
[3]	3	Ω VI 23 (B) Ω (A)	20d (AB)	Γ VII 13 (B) Γ (A)
[4]	4	Σ VII$^{!}$ 2 (B) Σ (A)	2m 1d (AB)	Ξ VI 3 (B) VI 3 (J) Ξ (A)
[5]	5	Ω II 2 (B) Ω (A)	18d (B) 15d (A)	Γ II 18 (B) II (AJ)
	6	Σ IX 25 (B) Σ IX 12 (A)	2m 4d (AB)	Ξ XI 29 (B) Ξ XI 16 (A) XI 28 (J)
[6]	7	Ω VIII 18$^{!}$ (B) VIII 20+x (A)	3d (AB)	Γ IX 1 (B) IX 1 (A) IX (J)
[7]	8	Σ V 21 (A) Σ (BC)	2m 11d (B) xm x+1d (A)	Ξ VIII 2 (A) VIII 2 (C) VIII (J)
[8]	9	Ω IV 25 (AC)	7d (BCD)	Γ V 2 (ACJ) Γ (D)
	10	Σ XII 25 (AC)		
[9]	11	Ω III 11 (AC)	9m$^{!}$ 4d (CD) 9m$^{!}$ xd (A) xm$^{!}$ 5d (F+J)	Γ XII 15 (AC) Γ (D) XII 16 (F+J)
[10]	12	Σ VIII 10 (AC)	2m 6d (C) xm 6d (D) 2m 16$^{?}$d (F+J)	Ξ X 16 (ACF+J)
[11]	13	Ω VI 26 (C)	11d (CF+J)	Γ VI$_2$ 7 (CF+J)
[12]	14	Σ I$^{!}$ 9 (C)	5$^{!}$m 16d (CF+J)	Ξ VI 25 (CF+J)
[13]	15	Ω II$^{!}$ 5 (CG)	7d (CFG)	Γ (CF+J) 12 (G)
	16	Σ X 20 (C) XI 21 (G) x+1 (F+J)	15d$^{!}$ (C)	Ξ XI ⌜21⌝ (C) Ξ XI 11 (G) Ξ (F+J)
[14]	17	Σ$^{!}$ VII 10 (C) VII 10 (G)	1m$^{!}$ 16d (C)	Ξ$^{!}$ VIII 26 (CG)

[15]	18	Σ V 20 (C) Σ V 21 (G)	2m 15d (C)	Ξ VIII 5 (C) Ξ IX 5 (G)
[16]	19	Ω V! 5 (C) Ω VIII! 5 (G)	15d (C)	Γ IV 20 (G) Ξ! V! 20 (C)
	20	Σ XII 15 (CG) Σ (H)	3m! 9d (C) 2m 7d (H)	Ξ III 25 (C) Ξ (G)
	21 (see 11)	XII 10 (C)	4d (CH)	Γ XII 14 (C)
	34	Ω VI_2 1 (C)	15d (C) 16d (M)	Γ VI_2 17 (C) VI_2 (M)
	35	Σ III! 25 (C)	2m 6d (C) 2m 16d (M)	Ξ VI 24 (C) Ξ (M)
	36	Ω I 27 (C)	7d (C)	II 3 (C)
	37	Σ (C)		XII 28 (C)

Table of Data in γ

Omen	Last visibility	Interval of invisibility	First visibility
38 (= 14)	Σ I 8 (K) I 8 (T) I (P)	5m! 18d (K) 5m! 17d (T)	VI x (K) VI 25 (T) VI 24 (P)
39 (= 36)	I 26 (PT) Σ! I 27 (K)	6d (T)	Γ II 3 (P) Γ (T) Ξ! II 3 (K)
40 (= 5)	Ω II 2 (KP) II 2 (T)	x d (P)	Γ II 28 or 18 (K) Γ (T)
41 (= 15)	Ω II 5 (K) 5 (T)	7d (T) 6d (V)	Γ (KT) III! (V)
42 (= 35)	III (V)	1? m! 9d (V)	Ξ (V) x+5 (K)
43 (= 4)	[IV] (V)		
44 (= 9)	IV (V)		Ξ! (Q) IV (V)
45 (= 19)	Ω (Q)		
46 (= 8)	Σ (Q)		Ξ (Q)
47 (= 18)	Σ (Q)	1+xd(O)	Ξ (A)
48 (= 3)	Ω VI 23 (A) Ω (Q)	20d (A)	Γ VII 13 (A)
49 (= 13)	Ω VI 26 (A)	12d (A)	Γ VI_2 8 (A)
50 (= 60; cf. 17)	Ω VII 11 (A)	1m 17d (A)	Γ VIII 28 (A)

51 (= 7)	Ω VIII 28 (A)	5d (A)	Γ IX (A)
52 (= 2)	Σ (A)	2m 8d (A)	Ξ X 19 (A)
53 (= 12)	Σ (O)	2m 8d (A)	Ξ X 16 (A)
		2m xd (O)	Ξ (O)
54 (= 6)	Σ x+1 (A)	2m xd (AO)	Ξ (AO)
	Σ 12 (O)		
55 (= 13)	Ω! 24 (O)	1m xd (O)	Γ! XI 28 (A)
	Ω! (A)	xm 4d (A)	Γ! (O)
56 (= 37)	Σ 28 (O)	2m 0d (A)	Ξ (OU)
	Σ (A)	xm 0d (J)	
57 (= 1)	Ω (AU)	3d (AJ)	Γ XI 18 (J)
			XI 18 (U)
			XI 28 (A)
58 (= 20)	Σ (AUV)	2m 7d (AJ)	Ξ (A)
			III 4 (J)
59 (= 21; cf. 11)	Ω (A)	4d (AJ)	Γ XII 14 (J)
	Σ! (V)		Γ (A)
60 (= 17; cf. 50)	Ω 11 (N)	1m 7d (R)	VIII 28 (R)
	Ω 3 (R)		VIII 27 (B)
	VII (B)		

Many scholars have been tempted by the possibility of dating this sequence of observations even though they faced the difficulties of translating dates in a Babylonian calendar wherein intercalation occurred in an arbitrary fashion into Gregorian equivalents, of computing phenomena of first visibility and first invisibility when the appropriate *arcus visionis* was not accurately known, and of choosing the best data when the dates of Ξ, Ω, Γ, and Σ of Venus recur on given days of synodic months at intervals of 56 or 64 years since the synodic period of Venus is less than 99 months (eight years) by 4 days, which means that it slips back by 28 days in 56 years, by 32 days in 64. Moreover, any solution using the data in omens 11 to 21 and 34 to 37 must drastically emend the text.

Nevertheless, the search for a solution has been made repeatedly. Two fragmentary tablets, A and C, were studied by Schiaparelli [1906/1907]. He assumed that the observations must date from the seventh, eighth, or ninth century B.C., and so computed that possible dates for the beginning of the series were -656 (or -664), -811, or -867 (or -875). Kugler [1912] pp. 257-306, relying on the identification of the Year of the Golden Throne with the eighth year of Ammişaduqa and setting -2060 and -1800 as the limits of the period in which Ammişaduqa reigned, computed that Ammişaduqa 1 corresponds to -1976/1975. Weidner [1914b] accepted the date -2000 without any astronomical argument, but in Weidner [1917] opted for -1808/1807.

Kugler [1924] pp. 563-571 and 622-627 recomputed the first year of Ammiṣaduqa to be -1800/1799. Fotheringham in Langdon [1923] vol. 2, p. iii, arrived at -1920/1919; this was supported by Schnabel [1925b]. Schoch [1925] placed the first year of Ammiṣaduqa in -1856/1855. Langdon-Fotheringham-Schoch [1928] gave astronomical arguments to reject -1808/1807 and -1800/1799, and non-astronomical (economic) arguments as well as the argument from full and hollow months to favor -1920/1919. Neugebauer [1929], reviewing Langdon-Fotheringham-Schoch, demonstrated the impossibility of using only the Venus Tablet to date the First Dynasty of Babylon.

A decade later, theorizing that the First Dynasty of Babylon must be dated later than had hitherto been accepted, Sewell in Smith [1940] pp. 26-27 and 50-52 claimed that -1645/1644 agreed with the data as well as did -1920/1919; Sidersky [1940] chose -1701/1700; and Ungnad [1940] elected -1659/1658. Neugebauer [1941a], reviewing Smith [1940], again pointed out that astronomy alone cannot determine the date of Ammiṣaduqa. Cornelius [1942] p. 7, fn. 2, claimed to have found that -1581/1580 is a possible date for the first year of Ammiṣaduqa. Using the new tables he had prepared (van der Waerden [1943a]), van der Waerden [1943b] and [1945-1948] supported Cornelius' solution, as he continued to do in van der Waerden [1965] pp. 34-47. Weir [1972] favored Sewell's dating, -1645/1644. Reiner-Pingree [1975], accepting Neugebauer's arguments, noted that omens 1 to 10 could be used as a check on dates for the first eight years of Ammiṣaduqa's reign, which must be shown to be in reasonable agreement with them, but that the data in these omens by themselves are insufficient to establish a date.

Huber [1982] combined the data of the Venus Tablet, which he purified by excluding 18 of the 49 preserved dates (one in omen 5, two in omen 9, two in omen 14, two in omen 15, one in omen 16, one in omen 17, one in omen 20, and all eight dates in omens 34 to 37), with attested 30-day (full) months and attested intercalations; statistical analyses of these combined data seemed best to fit the hypothesis that the first year of Ammiṣaduqa was -1701/1700, the date favored by Sidersky [1940].

But the most interesting part of the Venus Tablet for the historian of mathematical astronomy is section II, designated source δ. It is likely that δ was already included in α, and it is probable that α was compiled within a century or two of -1000; in any case, δ once existed independently since it was excerpted in at least monthly recensions of *Iqqur īpuš* (Labat [1965] pp. 205-239) as the last omens for Nisannu, Simānu, Kislimu, and Ṭebētu. *Iqqur īpuš* also contained a full transcription of δ; see Reiner-Pingree [1975] p. 63 (omens 22 to 27). The original of δ was simply a list of omens in which the phenomena of the protases were the first visibilities of Venus on I 2, II 3, III 4, IV 5, V 6, VI 7, VII 8, VIII 9, IX 10, X 11, XI 12, and XII 13; each protasis was followed by an appropriate apodosis. To these simple omens

were later attached supplemental protases and apodoses. The supplemental protases were based on the following mean periods of visibility and invisibility:

	Visibility	Invisibility
East	8 months 5 days	3 months
West	8 months 5 days	7 days.

One synodic period in this scheme consists of 19 months 17 days. If each month contained 30 days the synodic period would be 587 days; this appears a better approximation to reality than the 567½ days that would result from taking a month to be 29½ days long. This, the first attested approximation to a mean synodic period in Babylonian astronomy, must have been devised in the late second millennium B.C., and testifies to the fact that the periodicity of Venus' phenomena was already recognized by about -1000. The Babylonian theory is comparable to that of the Mayas (Thompson [1972] p. 66), for whom:

	Visibility	Invisibility
East	236 days	90 days
West	250 days	8 days.

The Mayan scheme yields a mean synodic period of 584 days.

Table of Data in δ

Omen	Appearance	Disappearance	Invisibility	Appearance
22	Γ I 2	Σ IX 7	3 mo.	Ξ XII 8 (read 7)
23	Ξ II 3	Ω X 7 (read 8)	7 days	Γ X 15
24	Γ III 4	Σ XI 8 (read 9)	[3] mo.	Ξ II 9
25	Ξ IV 5	Ω XII 10	7 days	Γ XII 17
26	Γ V 6	Σ I 11	3 mo.	Ξ IV 11
27	Ξ VI 7	Ω II 12	7 days	Γ II 19
28	Γ VII 8	Σ III 13	3 mo.	Ξ VI 13
29	Ξ VIII 9	Ω IV 14	7 days	Γ IV 21
30	Γ IX 10	Σ V 15	3 mo.	Ξ VIII 15
31	Ξ X 11	Ω VI 16	7 days	Γ VI 23
32	Γ XI 12	Σ VII 17	3 mo.	Ξ X 17
33	Ξ XII 13	Ω VIII 17 (read 18)	7 days	Γ VIII 25