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Observations and Predictions of Eclipse Times by Early Astronomers

by

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2.7 Accuracy of the Predicted Times

In addition to the hundred or so timed eclipse observations recorded in Late Babylonian history, there are about as many timed predictions. The majority of these relate to events that could not be observed in Babylon, for if the eclipse was seen then the observation rather than the prediction was recorded in Astronomical Diaries; the other predictions in the Diaries refer to eclipses that were not seen. Only in the Almanacs and Normal Star Almanacs do we find predictions that refer to eclipses that may have been seen at a later time by the Babylonian astronomers. In analysing these records, therefore, I am really trying to evaluate the Babylonian methods of making eclipse predictions largely from their failures. However, there is no reason to suppose that the Babylonian schemes would be less reliable when they predicted an eclipse which was not visible than when it was seen. I shall begin by considering the records of timed lunar eclipse predictions.

Table 2.7 lists all of the lunar eclipse predictions contained in the dated Late Babylonian Astronomical Texts for which a time is fully preserved. The records may be divided into three categories: umbral lunar eclipses that were visible somewhere on the Earth's surface but not necessarily at the longitude of Babylon (A), penumbral lunar eclipses (B), and failed predictions (F). Only the first category can be considered as being "successful" in the context of Babylonian astronomy. There are no firmly dated records of Babylonian observations of penumbral eclipses so the category B predictions can perhaps be thought of as "near-misses." Of the 56 eclipses listed in Table 2.7, 37 are in category A, 17 in B, and 2 in F. Thus, in this sample, the Babylonian predictions of lunar eclipses were successful about 66% of the time, with a further 30% being near-misses. Only 4% of the time did their predictions completely fail.

For the category A predictions, Table 2.7 gives both the local time of the eclipse as predicted by the Babylonian astronomers, and that deduced from modern computations. In making these computations, I have assumed that the predicted times relate to the expected time of first contact. The errors in the predicted times are shown in Figure 2.12. The mean error in the predicted times, about -0.40 hours, is shown by the dashed line in the Figure. This is sufficiently close to zero to confirm that the predicted times do indeed relate to the moment when the eclipses were expected to start. If the predicted times related to the end of the eclipse, then the mean error would be increased by about 3 hours, the average duration of the eclipses. If it were the middle of the eclipse that was intended, then the mean error would still be increased by about $1\frac{1}{2}$ hours.

The average accuracy of the category A eclipses is about 1.31 hours. There is no evidence for any improvement in the accuracy of these predictions down the centuries, mirroring the result found for the observed timings. This suggests that the same methods of making the predictions were used for the early predictions as for the later ones. I shall discuss the implications of this result in Section 2.8 below.

Returning to the category B predictions in Table 2.7, the predicted and computed local times have once more been given. However, these predictions relate to penumbral eclipses, and these events only have virtual contacts. Therefore, the computed time relates to the moment when the moon made its closest approach to the Earth's umbral shadow. The error in the predicted times are shown in Figure 2.13. Unsurprisingly, there is a much greater scatter in these times than there was for the category A predictions. The mean accuracy of these times is about 2.86 hours, more than twice as poor as that of the category A predictions.

Date	Description	Category	Predicted LT (h)	Computed LT (h)
-730 Apr 9	Omitted at 60° after sunrise	A	9.72	11.72
-667 May 2	Omitted at 40° after sunrise	A	8.04	9.33
-667 Oct 25	Omitted at 30° before sunset	A	15.64	14.90
-649 May 13	Omitted at 60° before sunset	A	14.86	16.75
-590 Sep 15	Omitted with sunrise	A	5.68	6.02
-572 Sep 25	Omitted at 35° before sunset	A	15.80	13.77
-525 Mar 24	... at 25° before sunset	A	16.35	13.80
-414 Mar 26	Omitted at 12° before sunset	A	17.28	13.47
-409 Jun 28	... at 70° after sunrise	A	9.50	9.72
-408 Nov 11	Omitted at 80° after sunrise	B	11.80	4.14
-395 Mar 26	Omitted at 10° before sunset	A	17.41	13.12
-379 Oct 22	... at 20° after sunrise	F	9.67	-
-378 Oct 11	Omitted at 12° after sunrise	B	6.95	9.36
-356 Feb 14	Omitted at 40° before sunset	B	14.77	14.91
-352 May 28	... at 7° before sunrise	A	4.52	5.83
-334 Dec 3	Omitted at 60° before sunset	A	13.09	12.36
-291 Aug 11	Omitted at 27° after sunrise	B	6.97	6.43
-278 Jun 19	... at 18° before sunset	A	17.95	18.19
-278 Nov 15	Omitted at 45° after sunset	F	20.29	-
-248 Apr 19	Omitted at 39° before sunset	B	15.89	9.11
-248 Oct 13	Omitted at 30° after sunset	B	19.78	21.93
-246 Sep 22	Omitted at 16° after sunrise	A	6.91	7.29
-232 Dec 14	Omitted at 74° after sunrise	A	11.91	10.67
-225 Feb 6	Omitted at 30° before sunset	A	15.34	12.65
-214 Jan 5	... at 58° after sunrise	A	10.54	9.88
-194 Jun 20	Omitted at 15° before sunset	B	18.15	18.99
-194 Nov 16	Omitted at 45° after sunset	B	20.26	23.83
-193 May 11	Omitted at 94° after sunrise	A	11.46	10.98
-191 Apr 19	... at 2° after sunset	A	18.63	17.91
-185 Jun 11	Omitted at 48° before sunset	A	15.92	13.27
-172 Mar 21	Omitted at 47° after sunrise	B	9.11	7.81
-169 Feb 16	Omitted at 31° before sunset	A	15.42	14.41
-169 Aug 13	Not seen at 4° before sunrise	A	4.94	5.60
-168 Jan 7	Omitted at 7° before sunrise	B	6.49	3.24
-162 Sep 23	Omitted at 48° after sunrise	A	9.07	9.04
-161 Feb 18	Omitted at 31° before sunset	B	15.45	8.39
-161 Aug 14	Omitted at 25° before sunset	B	17.10	17.11
-160 Feb 7	Omitted at 10° after sunrise	A	7.32	10.16
-158 Jul 12	Omitted at 58° after sunrise	B	8.75	8.09
-140 Jul 22	Omitted at 34° before sunset	A	16.76	14.43
-140 Dec 17	Omitted at 78° after sunset	B	22.20	1.94
-139 Jun 12	Omitted at 65° after sunrise	A	9.20	8.99
-137 May 22	Not seen at 35° before sunset	A	16.62	16.29
-136 Oct 5	Omitted at 79° before sunrise	B	0.81	2.77
-133 Sep 3	... at 30° after sunset	A	20.46	20.48
-132 Jan 29	Omitted at 92° before sunrise	B	0.62	6.51
-131 Jan 17	... at 60° after sunset	A	21.12	20.55
-122 Aug 2	... at 76° after sunset	A	20.49	23.99
-122 Dec 29	... at 6° before sunrise	B	6.59	8.73
-110 May 24	... at 61° before sunrise	A	0.95	0.35
-110 Nov 16	Omitted at 71° after sunrise	A	11.46	11.25
-106 Mar 11	Omitted at 62° after sunrise	A	10.27	9.73
-86 Aug 24	Omitted at 30° after sunrise	A	7.34	10.52
-76 Feb 9	Omitted at 76° after sunrise	A	11.68	11.77
-75 Jul 24	... at 8° before sunrise	A	4.47	5.17
-62 May 3	... at 9° after sunrise	A	5.89	4.49

Table 2.7: Timed lunar eclipse predictions.

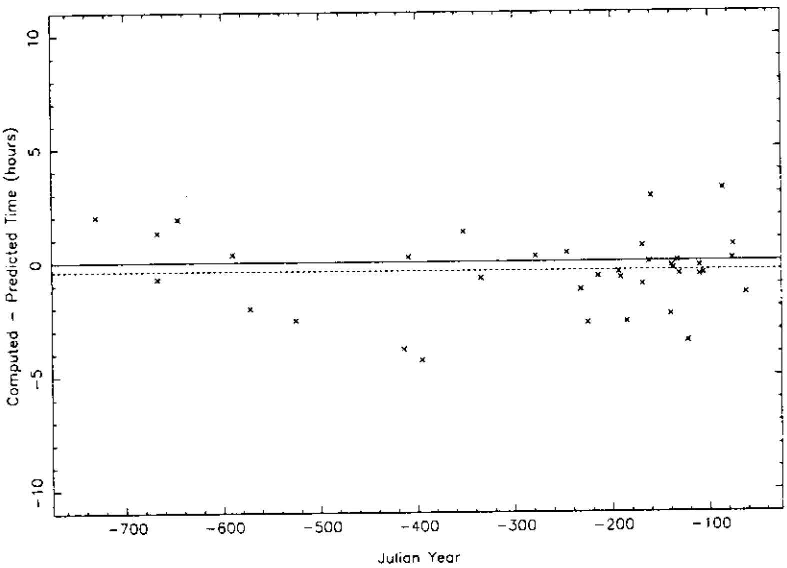

Figure 2.12: The error in the predicted time of the category A lunar eclipses.

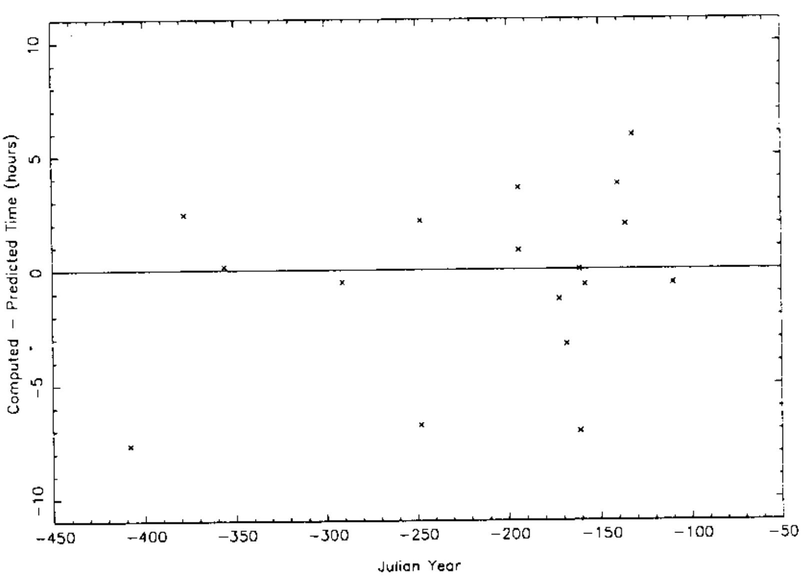

Figure 2.13: The error in the predicted time of the category B lunar eclipses.