Ptolemy's
ALMAGEST

Translated and Annotated by

G. J. Toomer

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Again, in the seventh year of Kambyses, which is the 225th year from Nabonassar, Phamenoth [VII] 17/18 in the Egyptian calendar [-522 July 16/17], 1 [equinoctial] hour before midnight at Babylon, the moon was eclipsed half its diameter from the north. Thus this eclipse occurred about $1\frac{5}{6}$ equinoctial hours before midnight at Alexandria.[58] The time from epoch is

[58] Oppolzer no. 1056: mid-eclipse $21;0^h$ (≈ 11 p.m. Alexandria), magnitude 6.1^d. P.V. Neugebauer gives mid-eclipse as ca. 23.6^h Babylon, magnitude 6.1^d. The time used by Ptolemy is clearly in error (although the computed positions of sun and moon must have seemed to him to confirm it), but the source of his error is too complicated to discuss here. The best treatment is in Britton[1] 81-4. For this eclipse (alone of those preserved in Almagest) there is also an extant cuneiform report (published by Kugler, SSB I p. 71). According to A. J. Sachs this text should be translated as follows: 'Year VII, month IV, night of the fourteenth, $1\frac{2}{3}$ double hours in the night a "total" lunar eclipse took place [with only] a little remaining [uneclipsed]. The north wind blew'. Here the time agrees with modern computations (and disagrees with Ptolemy), but the magnitude disagrees with both.

224 Egyptian years 196 days { $10\frac{1}{6}$ equinoctial hours reckoned simply
{ $9\frac{5}{6}$ equinoctial hours reckoned accurately

H420 (for the position of the sun was ♋ 18;12°).
Therefore the lunar position was as follows:

mean position in longitude: ♑ 20;22°
true position in longitude: ♑ 18;14°[59]

distance [in anomaly] from the apogee of the epicycle: 28;5°[60]
distance [in latitude] from the northern limit on the inclined circle: 262;12°.
Hence it is clear that, when the centre of the moon, again near its greatest distance, is $7\frac{4}{5}$° from the node, as measured along its inclined circle, and the centre of the shadow has the same position relative to it as before, half of the moon's diameter is immersed in the shadow.

But, when the moon's centre is $9\frac{1}{3}$° from the node along the inclined circle, it is $48\frac{1}{2}$′ from the ecliptic along the great circle drawn through it at right angles to the inclined circle [the orbit]; and when it is $7\frac{4}{5}$° from the node along the inclined circle, it is $40\frac{2}{3}$′ from the ecliptic along the great circle drawn through it at right angles to the inclined circle.[61] Therefore, since the difference between [the sizes of] the two eclipses comprises $\frac{1}{4}$ of the moon's diameter, and the difference
H421 between the above distances of the moon's centre from the ecliptic (i.e. from the centre of the shadow) comprises [$48\frac{1}{2} - 40\frac{2}{3} =$] $7\frac{5}{6}$′, it is obvious that the total diameter of the moon subtends a great circle arc of [$4 \times 7\frac{5}{6} =$] $31\frac{1}{3}$′.

From the same data it is easy to see that the radius of the shadow at the same greatest distance of the moon subtends $40\frac{2}{3}$′. For when the moon's centre was that distance [$40\frac{2}{3}$′] from the centre of the shadow, it was touching the edge of the shadow's circumference, because [in that situation] half of the moon's diameter was eclipsed. This is negligibly less than $2\frac{3}{5}$ times the radius of the moon, which is $15\frac{2}{3}$′. The values we derive for the above quantities from a number of similar observations are in agreement with these;[62] hence we use them, both in other parts of the theory, concerning eclipses,[63] and in the following demonstration of the solar distance, which will be along the same lines as that followed by Hipparchus. A further presupposition [of this demonstration] is that the circles of
H422 sun, moon and earth enclosed by the cones are not noticeably less than great circles on their spheres, and the diameters too [not noticeably less than great circle diameters].[64]

[59] Possibly one should read 18;11° with D[1] (computed: 18;10).

[60] Ptolemy has made a computing error here: correct is $\bar{\alpha} = 27;54°$. Obviously, he has computed (here only) for the uncorrected time of $10\frac{1}{6}^{h}$. However, this has no serious consequences, since it is merely intended to show that the moon is near the apogee of the epicycle. The discrepancy in the true position (see n.59) cannot be explained by this error.

[61] On the computation of these amounts see *HAMA* 107. It seems probable that they were, properly, computed from a spherical triangle with the right angle at the moon's orbit (rather than from a plane triangle or any of the other approximations suggested there). But the computations are inaccurate: Ptolemy should have found $48\frac{3}{4}$′ and $40\frac{5}{6}$′ respectively. For similar computations with the moon at the perigee of the epicycle see VI 5 pp. 284–5.

[62] Although Ptolemy's procedure for finding the apparent diameters of moon and shadow is both elegant and theoretically correct, it suffers from serious practical disadvantages. On these, and the inaccuracies involved in his actual computations, see *HAMA* 106–8.

[63] Reference to VI 5–7 and VI 11.

[64] I.e. in Fig. 5.12 the cones from points N and X enclosing the spheres of sun (ABG), moon (EZH) and earth (KLM) have bases (the circles on AG, EH and KM) which are not sensibly less than great