‡3 Hipparchos at Lindos: a Modest Confirmation

by DR[1]

A Hipparchos' Adopted Latitude

A1 While preparing the preceding article (‡2) for publication, I became curious about the modest disagreement regarding Hipparchos' calculation of the time M which the chosen star (υ Boo) — of declination $\delta = 27°1/3$ — spends above the true horizon: the M values computed by Neugebauer ($224°06'$: Neugebauer 1975 p.302) and Wilson ($224°07'$: ‡2 §B1) do not agree with that cited by Hipparchos, whose report is more precise than is usual for Hipparchos *Comm* phenomena. Stellar δ is effectively given to $2'$ precision,[2] and M is evidently being expressed to the nearest timemin:[3] $M = 15 - 1/20$ hours $= 14^{h}57^{m} = 224°1/4$ (Hipparchos *Comm* 2.2.26; pp.150-151).[4]

A2 In Rawlins 1994L, we found that Hipparchos' assumed latitude $\phi = 36°08'$ (Lindos vicinity) for calculating declinations from zenith distance observations. If we try that value (instead of the generally accepted round figure $\phi = 36°$) in ‡2 eq. 1, then we find $M = 224°21'$ which rounds to $14^{h}57^{m}$ or $15 - 1/20$ hours, as reported (§A1). By contrast, if we use $\phi = 36°$ in the calculation, the rounded result[5] is $M = 14^{h}56^{m}$ or $15 - 1/15$ hours, not Hipparchos' stated value.

B Excluding 36°N

B1 Next, we instead invert the problem and (via ‡2 eq. 1) simply seek ϕ from the attested Hipparchos values (§A1) for M & δ.

[1] See K.Pickering at *DIO 2.1* ‡2 §F10.

[2] The star's δ ends in $1°/3$, which means that pre-rounded δ was between $27°17'1/2$ and $27°22'$. (Hipparchos used degree-fifths for declinations: Rawlins 1994L §§F2&F4.) However, δ's precision does not affect the ancient calculation which is the subject of this paper — since it just used $\delta = 27°1/3$.

[3] The hour-stars of Hipparchos *Comm* 3.5 are sometimes expressed to 30ths or 20ths of hours — a one-timemin discrimination.

[4] Neugebauer 1975 p.302 n.10 correctly reports that Manitius confuses hour-fraction with timemin: Hipparchos *Comm* pp.151 & 298. Neugebauer 1975 p.166 n.3 suggests just the same type of scribal slip by an ancient. Note that precisely this sort of error turned out to be the ancient source of the slight discrepancy (in *Almajest* 4.11) of Hipparchos' assumed mean distance (of the Moon) for his eclipse-trio B analysis vs. that assumed for his trio A analysis. (See Rawlins 1991W §O3.)

[5] Exact result: $M = 14^{h}56^{m}27^{s}$.

B2 The result: $\phi = 36°05'$. (Which is the real value — as well as the anciently-known[6] value — for the latitude of Lindos: §C.) Taking M's precision as timeminutes, we check solutions for M between $14^{h}56^{m}1/2$ & $14^{h}57^{m}1/2$, finding that this constrains ϕ to the range:

$$36°00'22'' < \phi < 36°09'09'' \qquad (1)$$

— which does not include[7] the usually-presumed Hipparchos latitude $\phi = 36°$N.

B3 Moreover, the statistical analyses of Nadal & Brunet 1984 (see, e.g., their Table 5) concluded that the latitude used in Hipparchos' calculations was not equal to 36°N, but was a little higher.

C Lindos Re-Indicated

Thus, the foregoing provides a bit of confirmation of recent novel evidence (§A2) indicating that Hipparchos' main observatory was in the vicinity of Lindos ($\phi = 36°05'$N: §B2) — on Rhodos,[8] the Mediterranean island he is known to have worked at.

References

Hipparchos. *Commentary on Aratos & Eudoxos* c.130 BC. Ed: Manitius, Leipzig 1894.
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Note added 2016:

In 2012, at *DIO 20* ‡3 §A3, we caught on at last to what had been right in front of us for years: Hipparchos' eclipse calculations and his klimata mutually confirm two historically important discoveries:
[1] Hipparchos' mechanical calculational ability was unerring, and
[2] his era's trig tables were accurate to $1''$.
These realizations make the foregoing "modest" exploratory paper a good deal less modest. They mathematically confirm our finding by a completely independent induction (Rawlins 1994L or above at fn 8) that in his calculations Hipparchos used $36°08'$ for the geographical latitude of his observatory, which was very near Lindos.

[6] Rawlins 1994L fn 50.

[7] At first, it may look as if the left bound in eq. 1 can be rounded to 36°; however, one must realize that $36°00'22''$ is not a calculational output, but is instead simply the lowest input that will keep computed M within the bounds established in §B2.

[8] Rawlins 1994L §F3 showed only that Hipparchos' adopted value for his main observatory's latitude ended in precisely $08'$. However, from the Catalog's antarctic circle, Rawlins 1982C (eq.14) had already showed that Hipparchos' Ancient Star Catalog was observed at about north latitude $36°.2 \pm 0°.4$. Combining this information with the fact that Hipparchos' declinations indicate an observatory-placement error of $0' \pm 1'$ in latitude, Rawlins 1994L §G3 concluded that his central observatory was at $36°08'$N$\pm 01'$: near Lindos — probably just north of it.