Hipparchos’ Fake – 381/12/12 Mis-Eclipse
His Eclipse Calculations Used Pairs — Not Threesomes
Newly Confirmed By Resolving His One-Degree Fudge
Hipparchan Computations’ Mechanical Flawlessness
Greek Invention of Order-of-Magnitude Estimation

A Summary

A1 Hipparchos’ work with eclipse-trios (in the 140s BC) was mathematically analysed in 1991 by DIO, and all ³4 of the lunar-orbit elements (Almajest 4.11) Hipparchos had published were precisely elicited thereby at Rawlins 1991W, www.dioi.org/vols/w13.pdf, eqs.19-20&23-24, as generously noted in the History of Science Society’s Isis during its coverage (Thurston 2002S) of DIO’s reconstructions. These 4 solutions transpired through far simpler analysis and via more ancient-style round-number elements than prominent prior work (§A2) that failed to reproduce the same 4 data. § Analysis’ by-product: revelation that Greek science used order-of-magnitude. [DR thanks John Britton & the late Hugh Thurston for thoroughly and expertly verifying all of the mathematical steps of Rawlins 1991W. Also special thanks to Dennis Duke for inspiring, vetting, and tolerating the present paper.]

A2 The 1991 matches are so unanswerably perfect that they have never even been cited by the history-of-astronomy political center, the esteemed “Mufa”, which clings to its own goofy old theory (Toomer 1973), though it fits none of the 4 above-cited elements. (Unless one blatantly funnies input data: §K.) Nor does this cult-fave (C1, H2, I9&I10) theory explain Hipparchos’ data-fudge, a 2000 old puzzle 1s solved here at §G1 by extension of the gratifyingly fruitful 1991 analysis, which also bears a glimmer of early heliocentrism.

A3 Below, we precisely solve (§C2-G) both trios, achievable because Hipparchos’ calculations are always mechanically flawless (a point helping place his observatory near Lindos: see DIO 7.1 §3 end-Note), our historically key hitherto-implicit finding (Rawlins 1991W, confirmed: Rawlins 2009S Table 2) — ever-denied (e.g., fn 22) by DIO-shunners, who can only promote their predictable (Rawlins 1991W §H2 [g]) desperately weird anti-DIO pseudo-discoveries by dreaming-up Hipparchos (fn 10) & Strabo (Rawlins 2009S §B6) math errors at will. (Details of 30’s-shun’s tantrum-origin: see Rawlins 1991W §B.)

B Hipparchos’ Data

B1 Our subject here will be two much-discussed ancient lunar eclipse trios: from 383-382 BC (observed in Babylon) and 201-200 BC (observed in Alexandria). The trios are today generally designated as ‘Trio A’ & ‘Trio B’, respectively. (All six dates listed at fn 5.) Both trios were mathematically analysed by Hipparchos c.150-145 BC, during his primitive attempts to improve knowledge of the Moon’s nonuniform motion. The empirical data he started with were merely past reports of eclipses’ times (& magnitudes & durations), for which he computed true longitudes of the Sun (thus Moon opposite) from his solar tables of the moment. ² Hipparchos’ stated intervals are for two pair from each trio, ³ as follows:

¹ The Hipparchan numbers to be (re)traced here are: 3144, 3122 ½, 327 ¾, 247 ½. Rawlins 1991W solved all four to precision given. The paper’s calculated reconstructions are reprinted below: 3144 (eq.5), 3122 ½ (eq.6), 327 ¾ (arrowed A3-A2 at §G2), 247 ½ (arrowed B2-B1 at §F2).
²Rawlins 1991W §P2: all 4 unaltered Muff-nonts compared sidebyside with DIO’s 4 neat matches.
³Sociological background to such’s inevitability (DIO 4.3 §I5 §G9): banishers are unwittingly gambling — risking their reputations irrevocably on the improvident demand that the pariah is permanently valueless. Since no blackballing archon can admit to jailing valid ideas, the exiled journal can’t ever be credited for making a single discovery. So each time it does, its bet-reDoubling shunners must keep publicly faking its accumulating achievements’ worthlessness (welcome exception: §2’s fn 10 on its eq.4). See, e.g., DIO 4.2 §I9 §T, DIO 6 §3 §B2.
⁴Hipparchos’ adopted solar orbit varied from time to time, as we saw at §2 §O.
⁵ In temporal order, we call Trio A’s eclipses: A1 (382/12/22-23), A2 (381/6/18-19), A3 (381/12/12-13). Trio B analogously: B1 (200/9/22-23), B2 (199/3/19-20), B3 (199/9/11-12).
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B2 The Trio A time-intervals and longitude-intervals (Almajest 4.11):

\[
A2 - A1 = 177^d13^{3}/4 \quad 173^\circ - 1^\circ /8 \quad A3 - A2 = 177^d01^{3}/2/3 \quad 175^\circ + 1^\circ /8
\] (1)

The Trio B time-intervals and longitude-intervals (identem):

\[
B2 - B1 = 176^d06^{3}/2 \quad 180^\circ 20^\prime \quad B3 - B2 = 176^d01^{1}/3 \quad 168^\circ 33^\prime
\] (2)

C Precisely Solving the Origin of Hipparchos’ Lunar Distances

C1 Almajest 4.11 supplies Hipparchos’ disparate results for lunar distance \( R \) and eccentricity \( e \) (or, equivalently, \( r \)), epicyclic-radius \( r \)):

\[
\text{Trio A:} \quad R = 3144 \quad e = 327 2/3
\] (3)

\[
\text{Trio B:} \quad R = 3122 1/2 \quad r = 247 1/2
\] (4)

For decades after Toomer 1973, two of these desiderata, the lunar-distances \( R (3144 & 3122 1/2) \) were held by the political center (traditionally overlapping the O.Neugebauer klan) to be by-products of elaborate calculations, during which the prime sought-numbers occur and are then frozen-in-midstream: i.e., the very yardstick-radius of the lunar orbit \( R \) is supposed to just fall out of the process on-the-fly (\$18-19 & \$112-113) — unheard-of in Greek (or any other) mathematical astronomy. Including Indian.

C2 Rawlins 1991W precisely reproduced the \( R \) values by showing both were instead fixed at the outset, finding 3144 by just applying simple trip to Aristarchan data (Hipparchos was partial to such: \textit{ibid} fn 243 & \$08); half-Moon elongation 87" (or \( 3^\circ \) from quadrature: \$1 \( \$2 \), and Sun at distance 1000 Earth-radii (\$D). From \textit{ibid} eq.23, we have:

\[
R(\text{Trio A}) = 1000^\circ \cot 87^\circ = 1000^\circ \tan 3^\circ \approx 52^\circ 24^\prime 28^\prime \approx 3144^\prime
\] (5)

Perfect match to the attested value for Trio A’s \( R \) (fn 1). Notice that this \( R \) has thus established a startling revelation: measuring the lunar distance in solar-based units is the mark of a heliocentrist. And recall that all input data in eq.5 came from Aristarchos, who was the public pioneer of heliocentrism. (See also fn 6.)

C3 True, eq.5 doesn’t yield Trio B’s \( R = 3122 1/2 \). But instead of an impediment, this discord is about to be revealed as the clincher for eq.5’s source.

C4 One of the commonest ancient and modern misreadings of Greek numbers is the confusion of sixtieths with fractions. Evidently Trio B’s computer misread Trio A’s 52°24' (eq.5) as 52°1/2, thus (as 1° discerned at Rawlins 1991W eq.24)

\[
R(\text{Trio B}) = 52^\circ 1/2 = 52^\circ 02^{1}/2 = 3122 1/2
\] (6)

— the precise attested value for Trio B’s \( R \) (eq.4; fn 1). This delightful confirmation of eq.5’s heliocentrist revelation boosts our certitude that heliocentrism — lethally suppressed though it was (Rawlins 1991P) — carried on quietly in the astronomical community (as it did in 18\textsuperscript{th} century France), even showing up in the work of geocentrist Hipparchos.

No absolute Hipparchan value of any’s hour or longitude survive explicit. (Strictly differences: \textit{Almajest 4.11}.) But all of these dozen absolute data were precisely reconstructed at Rawlins 1991W §yy 9-10 & 12-3.

* Is it indicative that Hipparchos started with the eccentric lunar theory, rather parallel to the heliocentrist’s model for planets, but later moved over to the epicyclic lunar theory, parallel to the geocentrists’ model? Note it was the earlier (Trio A) computer who introduced (\$52) heliocentric measure into determining \( R \).

\* Duke 2008W, \( \text{JHA’s} \) August Pb paper, rejects (\$2 fn 10) all of DR’s 3 Hipparchos orbits (EH, Frankenstein & [Rawlins 1991H] UH), deeming them "neither conclusive nor satisfying" since (empth added) "parameters deduced from trio analyses are very sensitive to small changes in the input data" (shouldn’t that read "small errors"? — see \$2 fn 10 items [4]-[5]), from Duke 2008W’s unique delusion (\$1 SB4) that Greek solar data averaged 15° error. Only citation relating to target DR is nonexplicit: (JHA refereeing. Again.) But uncited Rawlins 2005 in 2012 explored this sensitivity, thus DR didn’t just compute orbit-elements from trio \( \text{ph} \) but the trio founds EH&UH were instead initially used and then subtly tinkered until perm or reasonably reconstructed: \$2 \|$K or Rawlins 1991W \$K, then tested against extant trios’ \( \phi \). Further testing found that a meld (correctly ordered, chronologically: \$3) of EH&PH fit Trio A’s \( \phi \), thereby establishing Frankenstein orbit & dating it to the −145 [V.Equinox] (\$2 \$O). Doubling UH requires rejecting \$2 eqs.3-4. (Contra pp.23-24 of the very Jones 2005 paper cited by Duke 2008W p.289 n.9.) UH — incl. above \$2 eq.4 — solved five mysteries simultaneously (Rawlins 1991H): [a] why Aristarchos & Hipparchos solstices are (\$2 \$C1) sole hourless \textit{Almajest} 3.1 Sun data; [b] all 3 Trio \( \phi \) (\textit{Almajest} 5.3&5); [c] \$5-\$6 discrepant of Trio C’s 2nd \( \phi \) [d] \$0.2 amplitude of AncStarCat zodiac stars’ periodic error; [e] Moon-phase when AncStarCat fundamental stars observed. (Also, suggestive: Hipparchos’ UH&AncStarCat — 127 A.Eqg epoch follows Meton’s S.Solst by 304/14, \textit{exactly} 1/16\textsuperscript{th} [Rawlins 2002a fn 17] of Hipparchos’ 4868\textsuperscript{th} Great Year: (2 \$P4).
motion) required tables for usage, which would take time to compile, thus Hipparchos’ continuing use of the old EH tables for a little while after establishing the PH orbit. This situation is consistent (§E2) with the – 382–381 longitudes (for the early eclipse catalog, long before the analyses of trios) being computed later than the – 200–199 ones — presumably c.–145, the time when (§2 §O3) he established the iconic (§2 §O1) PH orbit.

E4  Continuing in Hipparchos’ footsteps, we now compute (eq.7) the δ for all six eclipse-pairs. (Notice that for each trio, the sum of the three δ is zero.)

\[
\begin{align*}
\delta_{A2,A1} &= 172^\circ 53' - 179^\circ 46' 07'' = -6^\circ 53' 07'' \\
\delta_{A3,A2} &= 176^\circ 07' - 173^\circ 08' 04'' = +2^\circ 58' 56'' \\
\delta_{A1,A3} &= 11^\circ 00' - 7^\circ 05' 49'' = +3^\circ 54' 11'' \\
\delta_{B2,B1} &= 180^\circ 20' - 188^\circ 41' 24'' = -8^\circ 21' 24'' \\
\delta_{B3,B2} &= 168^\circ 33' - 159^\circ 46' 31'' = +8^\circ 46' 29'' \\
\delta_{B1,B3} &= 11^\circ 07' - 11^\circ 32' 05'' = -0^\circ 25' 05'' 
\end{align*}
\]

E5  Via likely roundings, Rawlins 1991W (§§M9&L2) reconstructs the absolute times of the six eclipses. Hipparchos’ mean anomaly for each eclipse was found through multiplying his traditional Aristarchan lunar mean-anomalistic motion (ibid eqs.6–7: not quite the same as Almagest 4.7’s) by the time since his theories’ epoch (Phil 1 = – 323/11/12: §2 §O3), and then adding the result to his equally Aristarchan lunar-mean-anomaly-at-eclipse \( g_0 = 82^\circ \) (Rawlins 1991W eq.9), which relates to apogee-at-eclipse \( A_0 \) thusly:

\[ g_0 = e_0 - A_0 = 178^\circ - 96^\circ = 82^\circ \] (8)

E6  This produces the following mean anomalies:

\[
\begin{align*}
g_{A1} &= 224^\circ 1/3^\circ \\
g_{B1} &= 297^\circ \\
g_{A2} &= 24^\circ 1/3^\circ \\
g_{B2} &= 105^\circ 5/6 \\
g_{A3} &= 177^\circ 44' \\
g_{B3} &= 246^\circ 
\end{align*}
\]

E7  Ere 1991, all presumed (from Alm 4.5) Hipparchos used eclipse-trios to find 3 unknowns simultaneously: \( e, g_0, \) & \( e_0 \). Rawlins 1991W §§N5f found he used not trios (which produce no matches: §A2) but eclipse-pairs (which do: §§F2&G2), thereby seeking only \( e \), while appropriating \( g_0 \) (see Rawlins 1991W §N10!!) and ultimately it seems (§F4) \( e_0 \) from a prior astronomer: eq.8. [A paper (§K1) rejecting the Pair Method cites Alm 4.5’s belief that Hipparchos’ method is that of Alm 4.6&11, meanwhile accepting the paper’s own 3438-base alteration of same.] To find \( e \) from an eclipse-pair, trigmaster Hipparchos used the pure-trig Pair Method (easier&clearer than Ptolemy’s eclipse-trio Simultaneous Method [§I1], though inferior in several ways):10 for any eclipse-pair we specify their 2 mean anomalies \( g \) (already computed at §E6) as \( \alpha \) & \( \beta \) and use them with \( \epsilon \) (§E4) in the 3-step trig procedure (perhaps unknown during the 21 centuries up to Rawlins 1991W §N13):11

\[
\begin{align*}
U &= -[(\cos \alpha + \cos \beta) + \cot \delta (\sin \alpha - \sin \beta)]/2 \\
V &= \cos (\alpha - \beta) + \cot \delta (\sin (\alpha - \beta)) \\
e & \quad \text{or} \quad \tau = R/(U + \sqrt{U^2 - V}) 
\end{align*}
\] (9) (10) (11)

\footnote{9 Where \( e_0 = 178^\circ \) is Aristarchos’ (later Hipparchos’&Ptolemy’s) lunar mean-longitude-at-eclipse; \( g_0 = 82^\circ \), his mean-anomaly-at-eclipse; \( A_0 = 96^\circ \), his apogee-at-eclipse (epoch = Phil 1: §E5).}

\footnote{10 The poorness of Hipparchos’ results alone suggests a primitive incomming with the sophisticated Simultaneous Method. (And the inconsistent consistencies of the 60-b based values of §F2 vs §G2 suggest worse.) As earlier realized by van der Waerden and shown at Rawlins 1991W (§§I & Rawlins 2009E, Hipparchos wasn’t an overwhelmingly able math-theoretician, though (contra Duke at §§K1&K4 & Jones at Rawlins 2009S §§G2–G3) an unerringly reliable computer: here & Rawlins 2009S Fig.1.)

\footnote{11 This presumes that Hipparchos didn’t solve pairs by trial. Note: all §E6’s \( g \) are round fractions (suggesting that some eclipse-data might’ve been slightly adjusted), except for the near-perigee (thus very sensitive) A3 case, where 1 unknown math (via §F4’s equation) upon pre-doctoral A3 yields \( e \) both outsized & negative. (An alternate explanation for Hipparchos’ fudging eclipse A3 by \(-1^\circ\).) The seeming good luck of Trio B’s consistency was bad luck, since it deluded Hipparchos into expecting similar consistency for Trio A; so when it didn’t happen, he made it happen: §§F3–G1.}

\footnote{12 Eq.6’s miscue indicates that at least the \( R \) of Trio A & Trio B were computed by distinct members of a hitherto (in 6) hypothetical Hipparchan stable. Note obvious parallel to the problems producing the few faked stars (Rawlins 1992T & Rawlins 1993D of Tycho Brahe. (Known to have had a stable.)}
Unfortunately, Hipparchos chose the 2nd solution (arced A3-A2) for publication, a solution squarely based upon fabrication. Its e (which of course would be rounded to 327'/3(2)) agrees with the attested Hipparchan value: eq.3. [Note added 2012/9/16. For both e&r, he picked the value nearest a round fraction (327'/2(3) = 6'/4) 247/12 = 4/3(4): which backs DIO’s theory (e.g., eq.8, fn 11, Rawlins 2002A fn A6) that ancient astronomers preferred round numbers for elements. (And for observational data: R.Newton 1977 pp.250-254. Newton’s discovery clinched by 30’ endings: DIO 2.3 $8 fn 47 & Rawlins 1994L fn 5.]

G3 Notice that we now not only have the fabrication but additionally have shown that it arises out of the theory that Hipparchos was mathematically investigating the lunar orbit via pairs not trios. The foregoing is therefore a surprise vindication — unanticipated in Rawlins 1991W — of idem’s Pair-Method explanation of the curiously skimpy (and explicitly-in-pairs) early data which Hipparchos&Ptolemy left us via Almagest 4.11.

G4 Check the 179° difference between Hipparchos’ pre-existing (ellipse-cartain: eq2) Frankenstein-orbit-computed solar $\phi_A = 257'/7(8$ (Rawlins 1991W $\phi_{M10}$) and the subsequently –1°-fudged lunar $\phi_A = 76'/7(8$ (ibid $\phi_{N15}$) — a forgery which naturally also shifted contingent $\delta_{A2A3}$ & $\delta_{1A3}$ from their $\phi$ values to the 1°-altered values of $\phi$1, which underlie $\phi_2$. [Hipparchos didn’t recompute ($\phi_1$) his eclipse catalog’s solar $\phi_A$ (to check vs lunar $\phi_A$) or spot R.’s $\phi_4$ deviation.] The 1° discrepancy has been known at least since R.Newton 1977 p.119’s clear explanation of the joke solar-speed which non-correction entails. (See also Hugh Thurston 2002S pp.67. Duke 2005T p.176-177 n.5 ignores R.Newton, DR, & Thurston, though doing so results in a wild solar-orbit eccentricity14 of over thirteen percent as 1° noted at Rawlins 1991W fn 162 [e = 86/80], & [non-citationally] agreed at Duke 2005T p.177 n.5). But no one (incl. Rawlins 1991W) previously realized that the error was due to a deliberate shift — to forge an orbital fit. Frankensteinorbit ($\phi_{E2}$) is obviously & variably superior (to a 13%-eccentric EH solar orbit!) — since its apogee-at-epoch $A_e$ (PH) and eccentricity15 e (EH) are much nearer reality (e.g., eccentricity 5% vs then-actually 4%) than the 13%-eccentric monstrosity required if 1°-fudge isn’t corrected-for.

Concluding this section: We have established Hipparchos’ adoption of a one-of-a-kind (and physically impossible) celestial configuration: a 179° difference of solar true longitude vs lunar true longitude for –381/12/12 mid-eclipse — adapted to paper over problems with his eclipse researches. In astronomers’ terminology: a mid-eclipse Moon at 179° true elongation — Hipparchos’ astonishing 1° fake, which has now ($\phi_1$) for the 1°time been fully solved, and thereby detected as fraud.

H Centrists & Rebels

H1 Several discussions of the Hipparchos trios have appeared in recent decades out of the history-of-astronomy center, e.g., Toomer 1973, Neugebauer 1975 pp.315-319, Jones 1991H, etc — along with two rebel studies, R.Newton 1977 pp.115-129, and Rawlins 1991W. The former authors all take the data as entirely real; the latter dissent (in differing fashions).

H2 Contra Rawlins 1991W, centrist authors propose (or accept) that, for each trio, Hipparchos’ analysis found unknowns simultaneously from his three-time data. It would indeed be possible thus to find three lunar-orbit unknowns; mean-longitude-at-eclipse $e_o$ (in degrees), mean-anomaly-at-eclipse $g_o$ (also in degrees); and eccentricity $e$ by Tria A or epicycle-radius $r$ (Trio B), either expressed in 60°th of a unit. But the centrist studies instead attempt to apply a newly (and wholly) invented Hunt&Freeze technique to go beyond what used to be the limit for three equations of condition, to try pulling from the data four unknowns — adding R to the hunt. (Though in their determination to conjugate e or r they)

14 Remember that what ancients (using adjusted circular orbits) called eccentricity was twice what moderns (using elliptical orbits) refer to by the same term. Rawlins 1991W fn 162 found that if eclipse A3’s = 1°-fudge is not accounted-for (i.e., undone), the data are consistent with $e = 7946'$ or 12.9 percent ancient convention; 6.5 percent, modern.

15 Again (fn 14): these $e$ values are ancient-convention. Modern equivalents would be half as large.

I Undead Fantasy: Non-Existing 3438-Radius Greek Chord Table

I1 The impasse here is based on a fundamental Mufia misunderstanding that takes for granted (“virtually certain” [Duke 2005A p.5]) that Hipparchos’ analyses of the 2 trios were by the elaborate method Ptolemy develops so ably at Almagest 4.6: from 3 eclipses’ times, solve for 3 planar lunar orbital elements simultaneously, thus here the “Simultaneous Method” ($\phi_{E2}$).

I2 Toomer 1973 claimed to have shown that Hipparchos used the Simultaneous Method, doing his trig by a chord table based upon circle-radius $R^2 = 3438$, which is the number of arcmin in a radian. Such tables were used the better part of a millennium later in India, which drew some astrology from the Hellenistic tradition, thus the superficial [Greek army left India 325 BC, two centuries before Hipparchos] plausibility of the Mufia’s refreshingly original idea. (An inspiration which must have greatly pleased Indian-astronomy specialist and fellow-BrownU scholar & mentor David Pingree.)

But there is not-a-shred of direct evidence that Hipparchos ever used such an odd device as a 3438-based trig table. Thus, Toomer’esque theorizing has managed to pioneer not-a-shredsquared here vis-à-vis Greek astronomy: $R$ being found on-the-fly (see below: $\phi_{E2}$), plus an Indian trig table flourishing centuries before its earliest attestation. And the Mufia claims to detest speculation by outlanders.

I4 What drew Toomer into his theory was the crude proximity of 3438 to both Hipparchos’ semi-major $R$ values: 3144 & 3122 1/2. When he applied the Simultaneous Method to Hipparchos’ data (3 distinct ways [$\phi_{E2}$] for each trio): during the cascading stages & mergings of the attempted 3438-based computational reconstruction, there inevitably appeared somewhere (anywhere would do) numbers that roughly approximated these two Hipparchan elements — though none came convincingly close to actually matching them.

I5 The most immediately obvious clue that Toomer — though admiringly masterful at the geometry involved — is pursuing a chimera is: if ratio 247/12 vs 3122 1/2 had not been based upon a start-out presumption of lunar orbit-radius 3122 1/2 (as shown above at eq.6) why would the ratio not be converted by Hipparchos to 99/1249, just like the conversion (below) of eq.19 to eq.18? (Even the same conversion-factor: 5/2.) This alone (and see analogously below at §§11&K3) tells us that lunar-mean-distance radius 3122 1/2 was adopted BEFORE not DURING Hipparchos’ calculation — a priority which is consistent with all known Greek astronomical work. Further indication (as noted at Rawlins 1991W
fn 244): 3144 & 3122 1/2 are within 1% of each other — a central point never even noticed by those promoting disparate on-the-fly origins for these numbers, thereby implying the super-proximity is just an amazing accident, (§K3), instead of wondering whether it was symptomatic of a common origin, which has turned out to be the now-obvious truth (§C4).

To effect his midstream-fallout version of the Simultaneous Method, Toomer follows the same calculation-procedure as Almajest 4.6. He starts by drawing a line from the Earth (point O in Toomer 1973’s diagrams) through any one of the three eclipse positions (points Mi, for i=1 to 3 or I to III, in his diagrams), calling B its other intersection-pt with the lunar orbit — and calling “s” the line-segment from O to B, a device that permits geometry to solve the problem. (In Duke 2005T’s revisitation of Toomer 1973, s is called d.)

Toomer adds to the speculative nature of his conception by supposing that Hipparchos did not use the Greek chord (crd) table of Almajest 1.11, where values range from 0 to 120 (angles 0°-to-180°):

Greek: crd α = 120 sin(α/2)  

— but instead for each trig calculation took a number c.180/π times bigger:

Indian: crd α = 6875 sin(α/2)  

I.e., Indian tables’ values range between 0 and 6875, being based upon a circle-radius of 3438 units.16 This ensures that each trig calculation is likely to produce numbers in the thousands. As each Toomer trio-calculation proceeds, one of these numbers of course may happen to hit near one of the two he’s looking for (either will do). (If neither desideratum turns up, he can try the same calculation by drawing line s through either (§H6) of the other two eclipses of the trio and computing on that basis. [See Toomer 1973 p.27 n.14.] During each trio’s Simultaneous Method analysis, R_i^2 = 3438 enters at step 3 due to the method’s dropped-perpendicular ploy [Alm 4.6].) Let’s watch it happen, starting with Trio A.

Toomer 1973 pp.13-14 Trio A successive line-segments (units of s, except last line):

| r = 3179 1/2 | 6674 |
| 5379 | 6248 |
| 3438 |

R = 6268/3438 = 1.823241344 [why not = 1.767? — see §I11]

\[ R/e = \frac{3134}{3438} \]

(Exact computation all the way through would instead produce 3135/335 = 627/67.)

Given that Toomer calculated his method from three different starting points (Toomer 1973 p.27 n.14), it is no great shock that somewhere along the way a number (3134 at §I8’s step 5) indeed pops up that’s near one of the Trio A sought-for R (3144) or e (327 2/3). The only genuine surprise here occurs when Toomer supposes that Hipparchos would at this point suddenly and selectively preserve the number 3134 all the way to the end of the calculation. (One can understand Toomer freezing such a number, since nearby 3144 is one of his goals. But why would Hipparchos care about packing this value into?!)  

When 246 1/3 (close to Hipparchos’ r = 247 1/2) appears (in step 3), it is not multiplied or divided in the steps that follow, thereby ensuring its suspended-animation-survival for ultimate display in a ratio for comparison to Hipparchos’. So the near-grail of 246 1/3 is captured only due to the choice to set aside and retain 3438 in the 3rd line of the above, while simultaneously merging four other numbers:

\[ \frac{2989 \cdot 1112}{2 \cdot 6750} = 246 \cdot 1/3 \]

(Easy calculation all the way through would instead produce 3135/335 = 627/67.)

16 There being 21600 arcmin in a circle, the consistent radius is that number divided by 2π: slightly less than 3437.34, the number of arcmin in a radian. The Indian table proposed for Hipparchos (Toomer 1973 p.8, Duke 2005T p.175) is effectively the Ptolemy (Almajest 1.11) table at 7°1/2 intervals (see also §1 fn 1) — with each Ptolemy chord-value enhanced by factor 180/π and integrally rounded (4-place precision). See Neugebauer 1975 pp.299-300, 319, 1116, & p.1132 Table 8.

10 The point becomes particularly relevant when we notice that the §I8 line (step 5) which produces \( R = 3134/3344 \) (in units of s) came from dividing numerator 6268 & denominator 6688 each by 2. But: why not divide by 2 again?! [Duke 2005T p.171 passes over same point when p.170 line 6 conjures-up 3144.] Why doesn’t Toomer simplify 6268/6688 to 1567/1672 instead of 3134/3344? (Previous line: exact calculation produces 6270/3438, so equitably dividing by common factors 2&3 produces 1045/573.) Not remarking the plain divisibility of 6268 & 6688 by 4, Toomer 1973 p.27 n.14 just says (emph added): “I suppose division by the common factor 2 here. It must have occurred at some stage in order to get Hipparchus’ final result.” (Same circular reasoning below: §HI4&K1.) I.e., prove Hipparchos used the 3-unknown method by assuming he did.

11 The foregoing §I10 failure-to-divide-by-2 revelation is just another example of an earlier point (§I5) regarding Trio B: the very r/R ratio being sought, (247 1/2)/(3122 1/2), would have immediately (after factors’ division by 5/2) become 99/1249. Similarly for Trio A’s r/R ratio: (327 2/3)/3144 → 983/9432. Why carry fractions in a fraction unless something fundamental is being held fixed? So it makes more sense to suppose that Hipparchos had adopted his R values (3144 & 3122 1/2) before his mathematical searches for e & r even started.

12 Toomer 1973 pp.10-11 Trio B successive line-segments (units of s, except last line):
Toomer 1973 pp. 11-12 reshuffles his diagram (admittedly falsely, supposing that Hipparchos made the same step inadvertently), and this time he gets (3082 2/3)/(246 1/3). Remarkably, considering Toomer has still missed by c.40 units a mark (3122 1/2) which Rawlins 1991W eq.24 was to hit infinitely more directly (above eq.6). Toomer concludes (emph added): “This is sufficiently close to Hipparchos’ ratio [R/r = (3122 1/2)/(247 1/2)] to prove that Hipparchus did indeed use a chord table of the type [here] posited in computing it.”

A few years later, the foregoing Trio B development collapsed when an input datum was found (Toomer 1984 p.215 n.75) to be based upon a false reading of miss. (Computation using the correct reading led to an r of about 231 [Duke 2005T gets 231.727: see below at §K1] instead of 246 1/3. So Toomer’s proof was a fantasy all along: the imagined match was purely coincidental.) To his credit, Toomer (at least temporarily) agreed that this correction “cast doubt” (loc cit) on his claim Hipparchus used a 3438-based chord table.

J Hipparchos’ Overconsistent \(g_0\) Reveals Aristarchos’ \(A_0 = 96^\circ\)

No one pushing Hipparchos’ use of Ptolemy’s Simultaneous Method (3 unknowns: \([\text{III}1]\) uses it itself to find mean-anomaly-at-epoch \(g_0\). As Ptolemy always did (Almagest 4.6), though Alm 4.11 cites Hipparchos’ solution for merely 1 unknown for each trio, comparing his own lunar \(e\) (or \(r\)) to Hipparchos’ but making no comparisons for the other 2 orbital data his 3-unknown method could find: \(g_0, e_0\). (Telling all but Mutillos if Hipparchos neither sought nor cited either.) Three-unknown-solving for \(g_0\) led DR to the entire trios-mystery’s solution (Rawlins 1991W §§N4&N10; Trio A’s \(g_0 = 81^\circ\); Trio B’s, 82°.6. While quite inaccurate (real \(g_0 \approx 87^\circ\); Alm’s, 85°.3), the \(g_0\) are near-equal (fn 9), shockingy so, given \(g_0\)’s sensitivity to input-data uncertainty, & [ii] the big disparities of Trio A’s \(e\) vs Trio B’s \(r\), and of the trio-analyses’ underlying solar approximations (21’ apart! [ibid §K9vs§M4]). These clues plus Rawlins 1991W §N10 are what suggested (ibid §§N4-N11) that \(g_0\) was not sought by Hipparchos’ math but rather was from a predecessor and thus set at 82°, so \(A_0 = 96^\circ\) (ibid §N5 & eq.9; above eq.8) for both trios from the start. Ibid §§N4&N17 assign these (poor) values to Aristarchos. But Trio B’s date could indicate lunar specialist Apollonios.

K Mythic-Centaurus Refereeing OKs Riggerous Mathematical Proof

K1 Nearly a third of a century after Toomer 1973, the journal Centaurus 17 published Duke 2005T, which attempted to salvage Toomer’s theory by (for each trio, at a chosen step) changing one number to (unlike above eq.5—eq.6) an unrelated number, to MAKE said theory fit. For Trio A, presuming Hipparchos mis-computed \(c_3\) (our \(\Delta A_1 - 9\Delta A_1 + \Delta A_1A_3\) as 51°'15’37’’ (though accurate Duke 2005T calculation would yield 51°30’23’’)— openly stating no other justification but that this was necessary to get the Right Answer: Duke 2005T p.170. (Similar to Toomer above: at §[10].) Quoting idem on Trio A (emph added): “In order to get Hipparchus’ answer we have to invoke some amount of rounding and miscalculation, so the first step is to adjust something so that the numerical value for the ratio \(R/e\) [3144/(327 2/3)] is produced. One simple way to accomplish this, out of an infinite 18 of choices, is to assume that Hipparchos miscalculated [51;30,23 of idem p.169] as 51;19,37, but did everything else precisely. Then he would get” the Right

17 Even beyond Centaurus’ imperviousness to the (credibly undiagnosed) ad-hockery of the proposed processes (esp. Trio B)— which led to DIO referee Hugh Thurstons’s rejection of them — there are printing problems here (none of which affect Duke’s uniformly accurate calculations). These again (as we saw at R.Newton 1991 fn 7, Rawlins 1991W fn 126, Rawlins 1996C §5b) reveal hollow refereeing at Centaurus: [a] Nest of misprints in p.168’s last paragraph (e.g., for \(\alpha_3 = 360° - \alpha_1\) read \(\alpha_3 = 360° - \alpha_1 - \alpha_2\). [b] At p.169 line 5, sign-typo; line 6, read 3135 1/7 for 3155 1/7. [c] Sign-slips in formula for \(R\), at pp.172&173. (Harmless: Duke uses correct sign in actual calculations.)

18 Ibid (pp.171&173) sees firm links between 3144&3438 and 247 1/2&3162; but each supposed link depends upon a specific choice of data-alteration among the cited infinitude of other possible options.

Answer19 by Alm 4.6’s method, there being “no question” (Duke 2008W p.286) he knew it.

K2 The one seeming “hit” here (presumably creating a sense of progress) is this: while Toomer 1973 p.15’s 3134/338 got neither the Hipparchan \(e/r\) ratio (327 2/3 vs 3144) nor either of its factors, Duke 2005T p.170 by contrast nearly achieves all simultaneously by discerning (§K4 below; Duke 2005T p.172) for Trio B suggests that Trio A’s match was just coincidence, a likelihood enhanced by the admitted \(\{\text{K1}\}\) huge range of options by which one may manipulate the Trio B numbers until finally (eq.15) getting lucky. And enhanced further by realization that an utterly different explanation (Rawlins 1991W) solves both trios exactly. Note the stark essential contrast between Duke 2005T and the present analysis: all DR solutions involve ancient-typically round numbers, are independently 20 supported and (unlike Duke 2005T p.172) equitably consistent for both trios (even the very same \(g_0\) & \(e_0\)), while Occamly forsaking adenuancement of convenient Hipparchos miscalculations. Summarizing: Aristarchos’ famous 87° recovers \(R = 3144\) (eq.5), which becomes 3122 1/2 (eq.6) via notoriously common misread (§C4); element-borrowing revealed by ultraclose \(g_0\)-agreement with 82° (§J, and see especially Rawlins 1991W §N10) for otherwise-jarring Trios A&B, thereby ruling-out the 3-unknown Simultaneous Method, which seeks \(g_0\) as an unknown.

K3 An extra problem with the entire initial presumption that Trio A’s 3144 & 327 2/3 materialized during a long mathematical juggle: were 3144 not fixed as R from the start, it would disappear through an obvious simplification; in a problem whose shaky input data & (discrepant \(e/r\)) would have suggested relative uncertainties of ordmag 10%, it would affect ratio \(R/r\) by barely 1 part in 1000 (ordmag 1/1000 of ratio’s uncertainty) to just round \(e\) to 328, to be more than factor 8 from numerator & denominator, leaving the near ratio 393/41. This point reminds us again (as at §[5]) that the proposed Toomerese-processes for the two trios involve (§[10]) so many arbitrary choices and cancellations, that it would be remarkable if the two \(R\) values agreed to within 1% by the accident implicitly proposed.

K4 For Trio B, a plainly unrelated number is again substituted for another (8:44.08 for Duke 2005T’s \(B_3,B_2 = 8:46:28\), again of just the right size that ratio \(r/R\) comes out equal to Hipparchos’. But even this ploy won’t produce Hipparchos’ absolute values for \(r/R\), as had been barely (fn 19) possible for Trio A; so, after this Trio B analysis gets as far as fixing the Right Ratio, a boldly arbitrary, Occam-defying \(e\)-ad-machina is brought in. A mere passing computation-facilitator (properly playing no rôle in final element-values of Ptolemy, Toomer 1973, or Duke 2005T’s Trio A, as noted: p.172), final-fiddle-factor \(d\) is now for Trio B ad-hoc-manipulated by just arbitrarily setting it at whatever (unattested) value neatly converts §K4-adjusted \(r = 231 3/4\) into 247 1/2 (p.172 step 5); namely, 3162.

K5 This also forces \(R\) to come out 3122 1/2 (step 8), since judgery of \(B_3,B_2\) (at §K4) had already been precisely designed to guarantee the process’ issuance of the Right Ratio (12.616, as found unmanipulatively at Rawlins 1991W §N14); which, if simply multiplied times \(r = 247 1/2\), produces the desired attested (eq.4) \(R = 3122 1/2\). The astonishing20
adducement of 3162 (yet-another goal-directed special assumption) is justified by some way-later (obviously not precision-addicted) Indian astrologers’ use of $\sqrt{10} = 3.162$ for $\pi$.

(Heard-of for Greek astronomy; & extant Indian records nowhere exhibit $\pi = 3.162$.)

In the step that produces $r$ ($\S 112$ step 3), instead of following Toomer’s arbitrarily freezing the numerator ($231.727$, after $\S 113$’s correction) it’s instead differently-arbitrarily treated: merged with its denominator (c.2960) and the result multiplied by $d$ = 3162:

$$r = 1000 \cdot \sqrt{10} \cdot 231.727/2960.39 = 247.53 \pm 247.1/2$$  

(15)

The equation for $R$ (Toomer 1984 p.11) then nearly becomes (Duke 2000ST p.173):

$$R = \sqrt{3162^2 + \left[\frac{247}{1} \right]^2} - 3162 \cdot \frac{106}{1} \pm 3122 \pm 1/2$$  

(16)

But eq.16 doesn’t work as printed (at ibid p.173): 106 1/7 is a harmless remnant resulting from one of a succession of shopping-trips seeking a way of fitting the calculation to Hipparchos’ results. (Back when $d = 3483$ was tried-out before going for 3162.) Once we switch fully over to $d = 3162$, the intended equation (which Duke actually & correctly computed with) appears [though exact math all the way yields $c.3122 \pm 2/3$]:

$$R = \sqrt{3162^2 + \left[\frac{247}{1} \right]^2} - 3162 \cdot \frac{972/3}{3} \pm 3122 \pm 1/2$$  

(17)

L Hipparchos in Toto

L1 $DIO$ has defied 100 of Experts’ mis-ascribing to Babylon Hipparchos’ amazingly accurate draconic period-sharing:

$$5458^8 = 5923^8 \approx [5849^8 + 147^8]$$  

(18)

(Where we’ve appended in brackets the seemingly hopeless anomalous situation, for contrast with near half-integrality below at eq.19’s precise resolution of the mystery of eq.18’s origin. Superscripts: $u$ = synodic months, $v$ = anomalistic months, $w$ = draconitic months.) Said consensus asserts that Babylonians used this equation c.200BC (long before Hipparchos), citing 6 cuneiform-text lunar data (Rawlins 2002H $\S D1$) calculated for that time.

$L2$ But (as noted at idem) there is a striking and perfect correlation here (which reminds us that ephemerides FOR a given year are frequently computed AT a quite different year):

- three of the six texts do indeed use eq.18
- but they are not dated on the clay — while all
- three of the texts which ARE dated on the clay (dated as created c.200 BC) DO NOT use eq.18. Ah, but there is a 7th text which is clay-dated — and uses eq.18. So that clinches it for the centrists? — No — ITS date is well after Hipparchos. (Full discussion: Rawlins 2002H $\S D$.) So the supposed impediment (to accepting Almajest 4.2&9’s attribution of eq.18 to Hipparchos) actually just adds — 7-times-out-of-7 — to the pro-Hipparchos evidences.

These evidences were already manifold, precise, and in some cases jaw-dropping. E.g., eq.18 can only be based on the standard Greek method of finding lunar motion (namely, eclipse-cycles) if an apogee-perigee eclipse-pair was used (Rawlins 2002H $\S B$):

$$13645^8 = 14007^8 \pm 14623^8 \pm 2^7$$  

(19)

$L3$ Division by 5/2 (like $\S 15$) produced eq.18. Clincher: the only eclipse-artist known to make the peculiar choice of apogee-perigee pair is Hipparchos. And he is attested (Almajest 6.9) as doing so using the very — 140/1/27 perigee lunar eclipse which Rawlins 2002H showed would precisely account for all eight digits in eq.18 if Hipparchos compared it to a (since-lost) record of — 1244/11/13’s apogee eclipse (instead of comparing it to the — 719/3/8 apogee eclipse he used for his 1st try: Almajest 6.9). We know period-sharing eq.18 is not from predecessors (as at $\S 3$) since he saw the — 140 eclipse (Almajest 6.5&9). Rawlins 2002H $\S C$ provides a detailed survey of the SIX-FOLD array24 of such testimonial, methodological, & quantitative verifications of Hipparchos’ authorship of eq.18.

$L4$ Discovery of precession is commonly mis-attributed to Hipparchos, though it was undeniably (Rawlins 1999) known to Aristarchos over a century earlier. So eq.18 is easily Hipparchos’ greatest scientific discovery. Rather than subtle math, finding eq.18 required dedicated determination: laboriously filtering extremely ancient records (over 1000 old to him) — obviously part of “the series brought over from Babylon”: Almajest 4.11) added to Aristarchos-level (www.dioi.org/cot.htm#tqdr) fine judgement in eclipse-choice. The result was ($\&$ is) accurate to 1 part in ordinate ten million. And not by accident. So, when considering Hipparchos’ lesser moments (due to the math limitations of himself & his colleagues, especially early on), we should keep in mind his marvelous处 —eq.18 advance of lunar theory,25 a decade-old $DIO$ discovery (Rawlins 2002H) still nowhere even understood (much less accepted) by hist.astron archendum, which gave up fighting us against instant-torpedo-reversal ($\S 2$) produced only the dreary longterm downder26

---23 Impervious to every item of this devastating series of childishly obvious indicia, our ever-ineducable $DIO$-denier klan instantly hurled its six-test kilo-wannabe torpedo (($\S 1$) at $DIO$. When that shot just-as-instantly backfired ($\S 2$), $DIO$ was hugely & at-the-time-gratefully (Rawlins 2002H $\S D1$) enlightened. But, again: Mufhosis learned nothing — and just skulkingly departed discussion without a word on their latest ideokiller-duo. It’s so efficient&comforting — and so like C.Polyem — to know answers ahead of incoming evidences, regardless of evidence after blow after blow after blow of such.

---24 The early eclipse records from Babylon may have been pretty dense at least in patches. How else explain that Hipparchos was able to search through and find a just-right match to establish eq.18?

---25 J.C.Adams’ 1846 Neptuneiasco (Rawlins 1999N) was followed by redemption through his brilliant, ultimately fruitful pioneering discovery (Rawlins 1992W $\S 12$) of lunar theory’s discord with observation, due to Earth-spin acceleration, the prime research field of the eminent Johns Hopkins physical astronomers, (eg. J.C. Adams, A.Robertson (Standish 1997), Isaac Hayes (www.dioi.org/hay.htm), R.Pearcy (Christiansen 1997), R.Byr (www.dioi.org/by.htm). [Also: fake-refereeing at some extremely handsome journals, e.g., Centaurs (just above; or fn 17) and Lord Hoskin’s sunloving (Rawlins 1991W J.B3 Journal for the History of Astronomy (www.dioi.org/jha.htm#kqz)]. But most of these figures left more positive than negative legacies. Is there a correlation between [a] exaggerations too often attendant to fundraising needed for great deeds, & [b] sham that also-too-often attends moments of falling short of greatness?
of finding no DIO math error, alternate eclipses, or equally accurate methods that could match DIO by eliciting all eight of Hipparchos’ digits. Exactly.27 Again: née-jerk archons yet lack the sense&balance to gauge, face, or admit the obvious uniqueness of our solution to one of the key equations in all ancient astronomy. In other words: the usual.


L6 The present article and the previous are our latest installments in DIO’s ongoing (from DIO 1.1 to date) expanded view of Hipparchos’ evolution from amateur (c. 160) into a serious contributor (c. –130) to the growth of astronomy. Our journey has been, like his and his science’s, a Niagara of surprises: the irresistible lure of the inductive journey.

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27 This holds for all three of DIO’s solutions of the origins of anciently-adopted lunar speed estimates: twenty-four digits in all, each reproduced exactly. Details: www.dioi.org/thr.htm & DIO 16 p.2.