2 Aristarchos Unbound: Ancient Vision

The Hellenistic Heliocentrists’ Colossal Universe-Scale
Historians’ Colossal Inversion of Great & Phony Ancients
History-of-Astronomy and the Moon in Retrograde!

I am restless. I am athirst for faraway things.
My soul goes out in a longing to touch the skirt of the dim distance.
O Great Beyond, O the keen call of thy flute!
I forget, I ever forget, that I have no wings to fly,1 that I am bound in this spot evermore.2

Summary

Genuine ancient astronomers made repeated use of the fact that the human eye’s vision-discernment limit is ordmag 1/10000 of a radian. Use of this key empirical figure is connectable (§F9) to all 3 of the huge astronomical scales attributed to the school of Aristarchos of Samos, the 1st certain public heliocentrist visionary. Evidence also suggests Poseidonios’ sympathy with (and enhancement of) this same vast heliocentric worldview (§F2), which entailed a universe a trillion times larger than the geocentrists’.3

A Muffia Vision

A1 Today, it’s widely supposed that the astronomy of Aristarchos of Samos4 (c.280 BC) was mostly theoretical; i.e., he is viewed within the constraints established by the fabulously logical reasoning of modern history-of-astronomy (hist.astron) on Greek science. For example, Neugebauer 1975 (p.643) presumes that all the work attributed to Aristarchos has “little to do with practical astronomy”. The famous “Aristarchos Experiment” based its ratio of the distances of the Sun&Moon upon the half-Moon’s occurring 3° sunward

1Likewise, the historian of things ancient has no temporal wings to fly into the past. He can experience bygone times only in his imagination. Rising from an evidential ground, he soars above it only by the strength of his inductive skills.

2From the Indian poet R.Tagore. This particular poem inspired Viennese composer Alexander von Zemlinsky to his most dramatic musical success: the first song of his 1923 Lyric Symphony Op.18. It should be stated explicitly that DR shares none of the mysticism of either artist. And I note that Dionysios the Renegade (c.300 BC), for whom I suggest (DIO 1.1 §1 fn 23) Aristarchos named the 3651/4 Dionysios calendar, based his philosophy ultimately upon hedonism. (Another part of the same Tagore poem contains the famous phrase, ‘stranger in a strange land’, now perhaps best known as an R.Heinlein scifi title. The phrase is not original with either Tagore or Heinlein. It is from Exodus 2.22 & 18.3. It also appears in Twain’s 1870 satire, “Goldsmith’s Friend Abroad Again”.)

3[Note added 2011: Trillion-factor based on cubing result of fn 72’s concluding ordmag-rounded calculation. (Without rounding: said factor will be an ordmag less,)] Rawlins 1985K proposes that the highly accurate Venus & Mars mean motion tables (major improvements to Aristarchos’ tables), underlying the Almajest 9.3 tables of those 2 planets, were originally designed for epoch Kleopatra 1 (−519/5). Chronologically, this is consistent with Poseidonios being among the promulgators of the original tables, whether or not based on his own work.

4Unlike most writers on ancient science, I use the Greek ending “os” (instead of the Roman ending “us”) for Hellenistic individuals’ names. (E.g., Hipparchos instead of Hipparchus. Of course, other DIO authors are free to spell as they wish in their own articles.) The particular situation that caused me to do this was the question: if scholars are so casual about endings that they unblinkingly refer to “Aristarchus of Samos”, then: is it equally OK to use “Aristarchos of Samos”? (Given Aristarchos’ revolutionary contributions, we note in passing that Samos was historically notorious for rebelliousness.)
of quadrature (eq. 4 below); but hist.astron-don Neugebauer 1975 (pp.642-643, quoted by Van Helden 1985 pp.6&167 n.8) claims that this is “a purely fictitious number” (part of a “purely mathematical exercise”), and that the data of a supposed lone extant Aristarchos, “On Sizes & Distances” — which DR ascribes to an otherwise unknown soon-after indoor mathematical pedant pseudo-Aristarchos — “are nothing but arithmetically convenient parameters [§3C], chosen without consideration for observational facts which would inevitably lead to unhandy numerical details.” (One might as well straight-out call Aristarchos an idiot. Such pontifications by the ever-intolerantly arrogant Neugebauer-cult — formerly known here as the Muffia — themselves ignore the crucial significance of a glaringly “unhandy” detail), the demonstrable falsity of the longtime attribution to Aristarchos of pseudo-Aristarchos’ grossly overblown unempirical 2° solar diameter. It is not a JHA-scorned modern novitiate, but no other than the immortal Archimedes, who says [and see additional confirmation at fn 33] that the real Aristarchos got-it-right,6 [§C1 item [a.]] Similarly, in 1984/6/28, O.Gingerich astonished a small Zürich gathering (including van der Waerden, myself, my wife Barbara, and others), by supposing aloud that Aristarchos’ heliocentrism was not really a full-fledged theory: perhaps he’d merely broached the idea one day while chatting with another scientist.

A2

See OG’s similar 1996/8 remarks (12° after the Zürich meeting) at Gingerich 1996 — projecting his own bizarre Aristarchos-demoting fantasy’ onto Hugh Thurston, who has informed me, in further astonishment (plus DIO 6 13 §H1) at the JHA’s old habit of careless mentalism (Rawlins 1991W §B1&B2, DIO 2.1 ddag 3 §C9), that this is naturally just Gingerich’s imagination at work. Art Levine’s satire comes to life yet again in the unique JHA!11 What follows will suggest that these Neugebauer-Muffia appraisals are as correct & perceptive as ever. (See also fn 70.)

A3

But I must call a brief interlude at this point, in order that the reader not miss the weird inversion going on here in §A1&A2, the Neugebauer-overall-ancient-astronomy-conception’s perversity-pinnacle: rebel&heliocentrist-pioneer Aristarchos was a non-observing-facility, while go-along-geocentrist&data-faker Ptolemy was antiquity’s

1 Indoor-Neugebauer 1975 p.642 astonishingly claims that “one would be lucky to determine the night on which dichotomy falls.” Contradict this (§& fn 19), sharp-eyed can discern “dichotomous½” whereness whenever “the arm [is] < 3°, as DR & K-Pickering have 1st-hand verified outdoors 100s of times.

2 DR deliberately chooses the very phrase banned from the JHA by Lord Horskin 1984/6/5 & others. (Uncited by Gingerich 1992K. Naturally.)

3 fn 11, which relays Levine’s spoof of his own WashMonthly’s penchant for projection, charitably as other writers reading WM accounts of their output “find themselves espousing ideas they’ve never even heard of, much less agree with.”

4 Ptolemy’s fraudulent tendencies did not end at mere fabrication of data. He had also a proclivity for suppressing all mention of inconvenient facts. E.g., when he pretended (Almajest 9.1) that the solstices of Aristarchos & Hipparchos were consistent with the Hipparchos PH solar theory (Rawlins 1991W §K10) adopted for the Almajest, he suppressed (DIO 1.1 16 §H1) the time of each of these 2 solstices and no other, of the score of equinox-solstice data provided thereabouts — thereby hiding the fact that each disagreed with said theory. (Each by the same amount: minus P/4.) Likewise, to

ABLE observer.10 For once, analogies fail me. No other fantasy in scientific historical analysis has ever been so Orwellianly wild. If some oddities are more unique than others, then this one is uniquely unique.

A4

Only in recent years have glimmers been detected (e.g., van der Waerden 1970 & Rawlins 1987) indicating that an ancient heliocentrist empirical13 programme existed. The analyses presented below are part of the fleshing-out of this realization. We have just (§A) sampled now-accepted Muffia Wisdom on this subject, but the depth & persistence of the comedy may not have been fully appreciated. Thus, desiring not to deprive readers by inadequately mining this rich vein, I will here quote from the widely-acclaimed book of history of astronomy archon A.van Helden, Measuring the Universe (1985), which embodies and disseminates Muffia orthodoxy in such matters (pp.9-10, emph added):

“[the Aristarchos Experiment] addressed only the problem of the sizes and distances of the two great luminaries [Sun & Moon]. No comparable geometric methods, however inadequate by our standards, were at hand for determining the sizes and distances of the other heavenly bodies. . . . he [Aristarchos] chose convenient [DR: this astonishingly uncomprehending word is taken straight from Neugebauer: §A1] upper limits for cosmic distances [eq. 14 here]. . . . very little astronomy was involved . . . . however, [Muffia] scholars have discovered much about Hipparchus’s achievements . . . and how he improved on Aristarchos’ approach to the problem of sizes and distances.

Comments on these precious Van Helden 1985 remarks follow:

A5

There is no sign here or elsewhere (e.g. fn 70) of Muffia appreciation for the critical point (made prominent in Rawlins 1987 and assertively detailed in Rawlins 1991P) that heliocentrist such as Aristarchos obviously knew the planets’ mean distances from the Sun in AU (merely the ratio of epicycle/denert radii for inner planets, inverse for outer planets), since the elimination of epicycles was, after all, the prime (Occamite) motivation for converting to heliocentrism! (See fn 7.) This is perhaps the most crucial achievement of concept (as against measurement: §1 fn 9) made by anyone in ancient astronomy. (See

prevent heliocentrist heresy from sullying his readers’ minds, Ptolemy at Almajest 9.1 discusses the question of whether Mercury and Venus circuit points above or below the Sun — but not the possibility (already entertained by Aristarchos and Théon of Smyrna among others) that these planets’ orbital center was virtually at the Sun. (Similarly, when dispensing with theories that the Earth moves or spins, Almajest 1.7 doesn’t mention heliocentrism.)

10See, e.g., the bizarre attempt to persuade Neugebauer 1975 p.284 (shamelessly followed by, e.g., Evans 1992, and Evans 1998 pp.273-274 & n.32 and even by Darbish & Efremov 2000 p.133 [which was refereed by Evans]) that Ptolemy was a better observer than Hipparchos. Obvious to the 2 mens’ relative errors, random & systematic: Rawlins 1999 §E3-E4. This particular hyper-inversion (started by Vogt 1925) is based merely upon the fact that semi-popular Hipparchos Comm commonly uses roundings which are much more crude than those in the Catalogue or those in Hipparchos’ declinations (Almajest 7.3). Furthermore, these apologia utterly and entertainingly conflict with those emitted by Huber (DIO 2.1 §2 §H), Swerdlow 1989, Graßhoff 1990, & Gingerich 2002, who contend that Ptolemy’s greatness in data-reportage was shown not at all by his alleged observations’ superior accuracy but rather through the contrary projection by which he either forged his inferior observations or replaced them by forgeries from theory? Question: Does an intellectually healthy and open community leave itself open to thoroughly spooing by getting into such pretzel-thought?

13Despite his 1897 K, Gingerich 1992K p.105 nonetheless persists in stating that there was “an absence of proof” of heliocentrism even as late as the 16th century. This though Gingerich 1992K (earlier on the same page) notes that the outer planets’ motion exhibited a peculiarity as cohesive as the inner planet orbital data cited at Rawlins 1991P §B1. (Uncited by Gingerich 1992K. Naturally.)

But distances are never computed in pseudo-A’s “Sizes & Distances”. (See Neugebauer 1975 pp.636, 639, & 643. Also Rawlins 1991W fn 220. Scrupulous and able mathematical analyses of this work are available by Heath 1913 and Berggren & Sidoli 2007.) Perhaps realization of the contra-outdoor-sky results (§C1) of such calculations stopped pseudo-A from continuing his ms.
§21 The claim that Hipparchos “improved” heliocristist Aristarchos’ measure of the universe is universally curiosus, since Hipparchos and other geocentrist probabitly put the stars at roughly Polenery’s distance (ordmag 10 AU), vs. Aristarchos’ ordmag 10000 AU. (See §E5. Actual distance of Proxima Centauri 270000 AU.) In brief, Muffiosis 15 regard it just as a meaningless coinicide that heliocristists proposed the biggest ancient universe. This achievement, of the finest ancient scientists, is passed off as just primitive, perhaps

15[Recently, O Gingerich has been trying to cope with this point. Without citation of DIO. Again.]
16 Van Helden 1985 p.19 appears to credit Hartner with the discovery that Polenery’s 19-to-1 Sun/Moon distance ratio was taken from Aristarchos, by quoting Hartner 1980 p.26 before quoting R.Newton 1977 p.199 (see also p.173 and R.Newton 1973-4 pp.382 & 384) with the same result. (Actually, the discovery of this revealing coincidence goes back at least to Delambre 1817 2:207. As suggested here at §E5: the coincidence may mean more than that the resulting was the lowest value then current among competent [read: heliocristist] scientists, which made it current enough with geocentrist that it survived. It is also a fun coincidence that the Aristarchan ratio 19 [eq.9] helps set up a neat fit for Polenery’s geocentric nested-sphere scheme. Regardless, the implied solar parallax still survived in Tycho’s work — at the dawn of modern astronomy. Given that Tycho openly branded Polenery a plagiarist [DIO 1.2 fn 154]: which of the 2 men [Aristarchos & Polenery] is more likely to have been the one Tycho trusted, when Tycho adopted this [inaccurate] ratio?]

The Hartner-RN citation sequence might be accidental. What is certainly not accidental is the total omission, from the Van Helden 1985 discussion of Eratosthenes, of 2 prominently published DR discoveries regarding that ancient’s work. (DR’s name does not foal a single page of Van Helden 1985. Standard for Muffisia archons’ output.) Van Helden 1985 p.5: “Since we do not know the precise length of the stade [Eratosthenes] used, it is fruitless to speculate on the ‘accuracy’ of his result. Suffice it to say that beginning with Eratosthenes the size of the Earth was known to the right order of magnitude.” Suffice it also to say that Van Helden 1985’s discussion is dense with misunderstandings. I regard the failure to cite here either Rawlins 1982G or Rawlins 1982N as a conscious, Muffiosa-kissing misleading of the reader, by suppression of evidence against the Muffia view propounded. Ie., the usual.

17 E.G., Swerdlow (fn 70), Neugebauer ( §A1), & Van Helden faithfully following (fn 70 & §A4).

numerological guesswork — even while the worthless & demonstrably (§F7) false numerological speculations of a succession of geocentrist and-or astrologers (see tables of Van Helden 1985 pp.27, 30, 32) are palmed off on the modern scholarly community as the best science available in antiquity, 16 without even referencing dissenting literature. A8 How could such a mix of innocence and prejudice (e.g., fn 14) adorn a standard (gov’t funded) history-of-astronomy survey volume, written by historian (& sometime JHA Adv Editor) A Van Helden? The answer is found in the ancient astronomy archens he depend upon. Van Helden 1985 p.vii (see also p.168 n.2): “In the course of this project I incurred many debts. . . . A Research Fellowship from the [NEH] . . . For the more especially the ancient [episodes] I have relied heavily on the researches of [Neugebauer capos] Bernard Goldstein [also sometime NEH beneficiary] and Noel Swerdlow.” (Van Helden 1985 was published by Swerdlow’s University of Chicago.)
B2 Thus, I realized at a stroke that all the famous Aristarchos astronomical scale measures could turn out to be consistent with the very same empirical base, namely, the limit of human vision was experimentally realized by Aristarchos to be about 1/10000 of a radian, or a little over 1/3 of an arcmin. (And this is about right for raw human vision: see fn 17.)

NB: It is attested that Aristarchos investigated optical science. (Thomas 1939&41 2.3.)

B3 It may seem remarkable that no one previously noticed this. But such an astonishing oversight is, in fact, precisely what one would expect of the history of ancient astronomy community as now constituted, since the enterprise is primarily into detailing-repeating the contents of ancient sources (and other safe-predictable sabbatical-length projects), and "original" research largely involves relating source A to source B — with but very occasional success at inducing the science behind either A or B. (Muffia disability here is seasoned with naked contempt for nonMuffia scholars who try.) Such work is more apt to encourage bibliographologists, than to thinking scholars. (Few Muffia capos are scientists. They naively presume that some mathematics background will suffice to protect them from misperceiving ancient methods; but: this presumption is just one more Muffia misconception. The idea that practical experience in relating empirical data to theory might be of use in doing history of science would seem to be self-evident. Not to Muffiosi.)

C Moon & Historians in Retrograde

C1 For roughly 2 millennia, since Eratosthenes († 1 fn 3) and Pappos (Rawlins 1991W fn 220), the allegedly Aristarchos work, "On the Sizes & Distances of the Sun & Moon", 19 E.g., Van Helden 1985 p.7 on Aristarchos' Experiment: "his method proved to be impractical. Even if he would have tried to measure his numerical data accurately, he would have found that determining the exact moment of dichotomy [half-Moon] and then measuring the angular separation of the two luminaries is a hopeless task." Mere echo of Neugebauer's equally indoor ignorance: fn 5.

20 Since a hallmark of the Neugebauer sales-cult is its consistent confusion of superstitious ravings (e.g., 3A3&K7) with genuine science, one can readily understand how this clique got into the habit of scoffing at the very idea of attempting to relate real science to ancient texts. See, e.g., Gingrich 1976's hyperagnostic-alibi-quotes defending Ptolemy (taken from Neugebauer 1975 pp.107-108), e.g., "It makes no sense to praise or condemn the ancients for the accuracy or for the errors in their numerical results. What is really admirable in ancient astronomy is its theoretical structure". (Compare such added archonal naïve to the realities of §9 and §13.) This astonishing bit of mis-megahistory (definitively vaporized at § 3A3&K4 and fn 9) was dashed up to excuse Ptolemy's Almagest 5.14 analysis, a fudgepot so incredible that even genial centrist W.Hartner calls it a "fairy-tale" (Hartner 1980 p.26). O.Gingerich's promotion of ON's rationalization appeared in the American Association for the Advancement of Science's main organ, Science. And it reflects official editorial policy at OG's extremely handsome Journal for the History of Astronomy (see fn 6). It would be pleasant, even if naïvely visionary, to imagine that DR might someday induce an astronomy-historian to attempt an experiment in empathy: imagining that he is the resurrected shade of a genuine ancient astronomer. In life, this scientist had spent decades [a] scrupulously testing (against observed data) various competing theories, and [b] empirically refining orbital elements & other astronomical quantities. He now returns to find 20th century archons slighting or ignoring this honest labor, instead preferring astrologers' lazy false-observations & other plagiarisms, maybe ripoffs of the shade's own original genuine work. Just the sort of appreciation scientists pour out their lives for. (See fn 67 & Rawlins 1993D §83.)

21 One amongst numerous instances (Neugebauer 1975 p.655 n.1): "The famous paper by Hultsch [1897] on 'Poseidonius über die Grössen und Entfernung der Sonne' is a collection of implausible hypotheses which are not worth considering." However, I urge nonMuffiosi not to emulate such arrogance and to instead appreciate that even illmannered bigots can make genuine contributions, which should be treated strictly on their merits.

22 There is also an implicit notion that avoiding offending archons will protect one from misadventure. Perhaps, but the level of scholarship resulting from such artificiality has been a contributing factor in judgement-degeneration that has cursed modern history of ancient astronomy. has been universally accepted23 as genuinely his. Rawlins 1991P (fn 6) and Rawlins 1991W (†R10 & fn 220) have challenged this incredible myth by exposing several internal problems of the pseudo-Aristarchos treatise. Perhaps pseudo-A's hazy perception of Aristarchos' astronomy is related to his resented corpus' near-extinction by the geocentrist establishment of his day. (See below: fn 69.) If we take "Sizes" as truly being Aristarchos', we must accept that one of the most eminent astronomers in history believed all of the following five nonsense-propositions (Heath 1913 pp.329f & 352f; Neugebauer 1975 pp.635f):

[a] The Sun & Moon are 1/150 of a zodiacal sign or 2° wide in angular diameter (nearly 4 times the correct value), thus pseudo-A's semi-diameter was:

\[
\theta_A = \frac{1^\circ}{4}
\]

(3) Rawlins 1991P fn 6 eliminated the contradiction by proposing that the factor-of-4 error was misperception. The idea that practical experience in relating empirical data to theory might be of use in doing history of science would seem to be self-evident. Not to Muffiosi.)

23 The failure of prior historians, to face the outlandish absurdities of the pseudo-Aristarchos ms, is a mystery. (None has previously realized that it entailed a retrograde Moon, despite our broad hints [fn 25] on earlier inside covers.) See, e.g., Heath 1913 p.350, Neugebauer 1975 pp.634-643 (which came nearest to fully realizing the ms' folly — but then attacked Aristarchos instead of the ms' attribution); also Evans 1992 p.68.

24 "Sand-Reckoner" p.223. With respect to the strange controversy (Rawlins 1991W fn 53) as to whether Aristarchos (also Timocharis & Aristyllos) used degrees: note that the various empirical magnitudes surely connected to Aristarchos are all easy fractions or multiples of degrees: 1/90 for 20 behind either A or B. (Muffia disability here is seasoned with naked contempt for nonMuffia scholars who try.) Such work is more apt to encourage bibliographologists, than to thinking scholars. (Few Muffia capos are scientists. They naively presume that some mathematics background will suffice to protect them from misperceiving ancient methods; but: this presumption is just one more Muffia misconception. The idea that practical experience in relating empirical data to theory might be of use in doing history of science would seem to be self-evident. Not to Muffiosi.)

25 The "Upcoming" lists (inside-cover) of DIO 2.2 & DIO 2.3 published warnings of this bomb well over a decade ago (1992): "Hist.sci accepts, as genuine, famous ancient treatise putting Moon into retrograde!" The JHA-H.A.D. crowd never picked up on the clue. Is anyone surprised?

26 See the equally-ironic comments at DIO-JHA 1.2 fn 284. The Neugebauer 1957 p.192 passage (there compared to p.206) was first brought to DR's attention by the late R.Newton.

27 In this handsome photo [www.doi.org/jha.htm#mns], the Moon is seen in its rising aspect (obvious to an outdoor astronomer) low behind the camera-facing Sphinx. But the Sphinx faces eastward.
Aristarchos: Ancient Vision  
2008 March  
DIO 14  

C3  
Let us see how the deliciously zany retrograding consequence ($C1[e]$) comes about. Pseudo-Aristarchos’ implicit mean lunar distance is (eq.5) $r_M = 20^\circ$.10 (where $1^\circ$ = 1 Earth-radius). But it is well-known that the Moon’s sidereal period is & was $27^{2}2^{3}/2$ (mean sidereal motion $0.549$hr) or 27.4 sidereal days. So an observer on the Earth’s Equator, watching the Moon (with mean distance & motion), transiting in the zenith, must therefore be travelling $27.4/20.10 = 1.36$ times faster than the Moon, which will thus appear to be moving in reverse at about $0.2/hr$ — the peak-speed of a (diurnal-synodic) retrograde loop (similar to the annual-synodic retrograde loops familiar to planet-watchers).29

C4  
Recall another serious problem with the pseudo-A work. We will define $\gamma$ as the half-Moon’s angular distance from quadrature. Rawlins 1991P §C1 suggested that the famous Aristarchos value

$$\gamma_A = 3^\circ = \arcsin(r_M/r_S) \approx \arcsin(1/19)$$

was an upper bound, not a precise figure. (The notation: $r_M = $ the Moon’s distance, and $r_S = $ the Sun’s distance.) Even allowing this,32 Rawlins 1991W fn 272 showed that as merely


29The pseudo-Aristarchos Moon, at mean geocentric distance 20.10, will travel 20.1 times farther per Earth-circuit than will an observer on the terrestrial Equator. But this circuit will take 27.4 times longer to perform. Thus, as noted above, the mean geocentric speed of the equatorial observer must be 27.4/20.1 = 1.36 times greater. When the Moon is in the equatorial observer’s zenith, he is only 19.1 distance from pseudo-A’s Moon, so the Moon’s relative hourly angular “topocentric” or observer-centered motion is (20.10−27.4)/(20.10−1) times the mean geocentric sidereal hourly lunar motion ($0.549$) or: ~0.2. (Obliquity’s $\cos = 92\%$, ignorable for rough mean-situations: [a] when the Moon is on the Equator, its motion is not parallel to the terrestrial observer’s meridian to them; [b] when the Moon’s geocentric motion is parallel to the Equator, the Moon is not on the Equator.)

30Maximum apparent retro-motion would always occur around lunar transit (which is one reason why §C2 calls National Geographic’s faked rising-Moon photo irrelevant to the present discussion), analogously to an outer planet’s motion near opposition. This entire effect may sound as if it is purely theoretical, whereas there is in fact a readily-discriminable slowdown of topocentric lunar angular speed when the actual (not ancient-theoretical) Moon is high. I.e., there is a retrograde tendency, due to the Earth’s spin; but in reality this superposed parallactic motion’s speed is — due to the Moon being about 60° (not 20°) away from the Earth’s center — not fast enough to overcome the Moon’s own sidereal motion. For the real equatorial overaat Moon at mean distance & mean sidereal speed, the equatorial observer will be traveling only 27.4/60.27 times the Moon’s sidereal speed, so the Moon’s absolute topocentric $0.56/hr$ speed is slowed to a relative angular speed of about $0.3/hr$. (When the Moon is near the equatorial nadir, this relative speed would be seen — if it were visible — to be $0.8/hr$. Over time, the speed must of course average out to the mean lunar geocentric sidereal speed: $0.549/hr$.) This generally-neglected effect (which I have frequently observed firsthand — and without optical aid during temperate-latitude high Moon-star appulses) could easily have been measured by the ancients, to yield a useful estimate ($\gamma_A$) of the Moon’s distance $r_M$. Yet another reason for the incredibility of the wildly false values for $r_M$ entailed by pseudo-Aristarchos. Without that, is that, both the emendations here suggested (in $\theta$ & $\phi$), lead to the reasonable values found in eq. 11.

31A weird variant of DR’s upper-bound approach (to explaining Aristarchos’ 3°) appears in Evans 1998 p.72. (With no citation of Rawlins 1991P.) Though Evans speaks of “least perceptible” inequality in crecent and gibbous portions of the month (without asking how the $\gamma = 3^\circ$ boundary between these portions is determined!) — a difficulty which throws us right back into the mire of the very problem allegedly being solved, he says Aristarchos “simply made up the value” — faithfully converting a physical argument (“perception”) into the orthodox Neugebauerian cited above at §A1.

32As early as Archimedes (p.223), Aristarchos was cited as claiming that the Sun/Moon distance ratio is between 18 & 20 (prop.7). At first glance, it might seem that this bracket reflects data-precision. Hardly. [a] The range indicated is purely mathematical (not empirical). (See Heath 1913 pp.376-381. The math is a geometric approach to a problem more accurately done by either simple circle-math [like that of [C5] or by trig, which could suggest that trig did not yet exist c.280 BC. For contrary evidence c.275 BC, see Rawlins 1985G p.261 & fn 9. The two evidences together may indicate

an upper bound, said 3° figure depends upon visual discernment of ordmag 1/10000 of a radian — c.1/3, very near the limit of human ocular discernment. (I am of course taking it for granted that the fineness of human vision has not changed significantly since 280 BC.)

C5  
We have seen earlier from Eusebius (§11 eq.14) that Eratosthenes placed the Moon at a distance of 19 Earth-radii, a figure presumably gotten from pseudo-Aristarchos. (Unless universe-shrinking Eratosthenes was himself pseudo-A. The document’s curiosities [e.g., §1 fn 4] cannot be traced back beyond Eratosthenes.)33 And this is the figure computed from pseudo-A’s propositions 11&17 at Heath 1913 pp.338-339. Yet Heath bases this upon averaging depressingly crude brackets associated with needlessly pedantic geometric proofs. By contrast, an exact computation (e.g., Neugebauer 1975 p.637) finds 20 Earth-radii instead of 19:

$$r_M = 1 + \sin \gamma_A (1 + \tan \phi \sin \theta) \approx 20^\circ.10$$

using pseudo-A’s false data ($C8 & eq.2$): shadow-Moon ratio $\psi = 2$ and solar semi-diameter $\theta_0 = 1^\circ$. Question: if you wished to find 1/sin $1^\circ$ or (virtually the same) the distance/size ratio for something subtending $1^\circ$, wouldn’t you just figure that the circumference is $2\pi$ times the distance and $1^\circ$ is 1/360 of that, so distance/semi-diameter = 360/2$\pi$ = 57.3? (The pseudo-A brackets instead can only put the number somewhere between 45 & 60! It’s hard to accept that Aristarchos was this limited.) Is there a more reasonable explanation for why a very simple computation which should have produced 20 instead got 19? [Our next speculation parallels known Hipparchan researches: Alm 5.11.] Try this: since DIO has for years pointed out ($C4$) that $\gamma = 3^\circ$ is probably an upper bound (not an exact figure), why not explore the obvious consequence of this assumption, namely, that Aristarchos (not knowing where $\gamma$ was in the range 0° to 3°) simply made it null for solar distance $r_S \approx \infty (\gamma = 0^\circ)$? In that case, eq.5 becomes:

$$r_M = 1 + \sin 0^\circ (1 + \tan \phi \sin \theta) \approx 19^\circ.100$$

(6) (More efficiently: $r_M \approx 60^\circ \pi \approx 19.1^\circ$.) So, Eusebius’ verification that a lunar distance of 19° was an accepted figure turns out to lend potential if as-yet-speculative support to the common-sense DIO theory that eq.4’s $\pi \approx 3^\circ$ was indeed ($C4$) an upper bound for Aristarchos, showing his openness to the possibility that the universe was many times larger than that implied by taking the 3° figure as exact.

that the early 3rd century BC was the transition period when newly-invented trig was widely but not universally used by mathematicians. Or, Aristarchos may simply have opined that geometric clothing for his demonstration would enhance its academic impact. [b] The implied visual precision would be impossible, anyway. The range (18 to 20) corresponds to $\gamma$ equalling $3^\circ \pm 0.16$ — which in terms of visual discrimination corresponds to half (fn 17) of $1^\circ/4$ (lunar semi-diameter) times $0.16$, or barely $1^\circ$, clearly not visible. Rawlins 1991P §C1 regarded 3° as an upper bound. No other empirical interpretation makes sense. And we now find here that this seemingly speculative interpretation has led straight into realization of its consistency with Aristarchos’ other cosmic-measure work: §B1.

33Has it been previously noted that Aristarchos’ near-contemporary Archimedes (probably a few years older and light-years brighter than Eratosthenes) reports none of the follies of pseudo-Aristarchos? (Which perhaps sandwiches the time of pseudo-A’s origin into the 2nd half of the 3rd century BC). The nearest he comes is in referring to Aristarchos’ Sun distance-ratio as being between 18&20, a mere confusion (identified elsewhere: fn 32) of geometric method with precision. But Archimedes doesn’t repeat any of the key giveaway screwups of pseudo-Aristarchos: 2°-wide Sun (indeed, he contradicts it), lunar distance 19°, Earth-shadow/Moon ratio = 2. Note also the clash between Archimedes-Aristarchos 15) and pseudo-Aristarchos (Heath 1913 pp.339 & 350) on $\pi$: 10000° vs 360°, respectively. Were Aristarchos’ works more welcome in Archimedes’ Syracuse than in Eratosthenes’ Alexandria (by then of less-Greek rulership, and fiscally strained from funding wars, e.g., Pyrrhos)? See §II §F3. (What Alexandiria instrumental star data survive from the 100° after Aristyllos, 260 BC?)
In addition to the flock of pseudo-A difficulties cited above (§C1 & fn 32), Rawlins 1991W §R10 also revealed a hitherto-unnamed internal contradiction in the pseudo-A work: the explicit (and false) statement that 1/3960 of a rt angle is too small to be visually discerned (Heath 1913 p.370, Neugebauer 1975 p.640). However, 1/3960 of a rt angle is 4 times bigger than 1/10000 of a radian. So, this pseudo-A statement wipes out the entire visual basis (fn 17) of Aristarchos’ Experiment!

The foregoing shows (in overkill proportions) that the pseudo-A treatise is not to be accepted as the output of a competent astronomer. One may assume either: [a] Aristarchos was a fool (fn 34), or [b] the work is not by him. I prefer option [b]. However, more important than the author’s identity,34 is the astronomy behind pseudo-A.

Having thus already ([§C1a]: “ἐπιστήμη”]) cleared up pseudo-Aristarchos’s most obvious absurdity (eq.2: 1° lunisolar semi-diam ρ60, we check another highly suspect pseudo-A statement, namely, that, at the Moon’s distance, the pseudo-Aristarchos ratio ρ6 of the Earth’s umbra (shadow-width) to the lunar angular-diameter is just 2. (Computing with accurate v is crucial for finding the lunar distance: eq.11.) But this v would (eq.10) cause central eclipses’ Entirety (Partiality + Totality) to be 3 times longer than Totality. Letting ρ stand for the Entirety/Totality ratio, we have pseudo-A’s ρ6 = 3 (eq.10). But it is well known that an eclipse’s maximum possible Entirety is instead just under 4, while maximum possible Totality is slightly more than 13/4 — that is, roughly 2½ — creating an Emt/Tot ratio ρ of barely 2 (far short of Emt/Tot = 3). For the mean distance situation, the actual shadow/Moon ratio v is 2.7 (corresponding to Emt/Tot ration ρ = 2 1/6: fn 35). And we know that Hipparchos used v = 2.5 (Almajest 4.9), while Ptolemy used v = 2.6 (Almajest 5.14, §C8). How could an observing astronomer set v = 2.7? The basis for estimating v is eclipse records. (And Aristarchos may have researched and drawn wisdom from such records more than any other Greek of his day: DIO 11.1 §1.) The simplest method would be to use central eclipses (Earth-shadow & Moon concentric at mid-eclipse): those for which the lunar path virtually bisects the shadow. By averaging a few empirical distance data from such central events, one may (eq.7) compute v from the ratio ρ of the time of an Entire umbral eclipse to time of Totality (for central eclipses), which is (crudely) 4v2/3 ≈ 2, a figure that reveals (via eq.7) v to be much nearer than 3 than 2. Even aside from Aristarchos’ access to centuries of Babylonian eclipse records, he could have observed first-hand the 21-digit eclipse of −286/5/20 (ρ = 2 1/5); and--or the 19-digit eclipse of −279/6/30 (ρ = 2 1/4), which occurred just a few days after his famous S.Solstice observation. Such easy observations would make it clear that v was nowhere near 2. One possible cause of pseudo-A’s wacky v = 2 is amateurish confusion: pseudo-A carelessly took ρ (something about in-shadow, wasn’t it . . . ?) to be v. (We already know from §§A1&C1 how easily confused pseudo-A was.) Keep in mind: the Entire/Eclipse ratio ρ is an easy raw-empirical number; while v is derivative. Another possible explanation of the pseudo-Aristarchos v-vs-ρ foulup arises quite naturally from an examination of the neat inter-relationship between v and ρ:

\[ v = \frac{\rho + 1}{\rho - 1} \]  
\[ \rho = \frac{v + 1}{v - 1} \]

Equ. 7 is a special case (where constant α = 1) of what I’ll call the “Reversible Fractional Function” (RFF):

\[ y = R(x) = (x + a)/(x - 1) \]

It is not immediately obvious that the deceptively simple expression \( R(x) \) brings out the fun in function — by the following cute property:

\[ y = R(x), \text{ then } x = R(y). \]

Had the real Aristarchos genuinely believed \( v = 2 \), he must have realized that this correlated (again via eq.7) to \( \rho = 3 \) — which was plainly false, as anyone of the slightest experience with eclipse records would know. But we recall ([§C8]) that actual ρ just55 exceeds 2, and no lunar eclipse datum is easier to find. Thus, it is not credible that Aristarchos would opt for \( \rho = 3 \) — a value nearly five times as far from the truth as that which I will here suggest was actually his original, namely, a rounding of the crude \( \rho = 4/28 \) ratio noted in [§C8] as too plain to miss, that is: \( \rho_A = 2 \). And this entails (via eq.7) a comparably better value for the shadow-lunar-ratio \( v_A \), so we can be pretty sure Aristarchos used:

\[ \rho_A = 2 \quad v_A = 3 \]

Note that, if we accept pseudo-Aristarchos, eq.9’s roughly valid values became reversed into ridiculous falsity:

\[ \rho_p = 3 \quad v_p = 2 \]

Thus, in brief, inspired by our [§C1] revelations of pseudo-A’s unreliability, I am suggesting ([§C8]-C10) that pseudo-A, through sloppiness or enslavement by symmetry (of the eq. 8 RFFunction), either: [a] misunderstood a reference to ρ (commonly known to be about 2) as a reference to v, or [b] simply confused Aristarchos’ \( \rho_A = 2 \) \& \( v_A = 3 \) with each other! (Easy mix-up for an amateur, since, as eqs. 7&6-9 have revealed: when either of the two variables equals 3, the other equals 2. Note also cylindrical-shadow confusion at fn 34.) Let us now explore the consequences of this simple (though speculative) hypothesis.

We substitute eqs. 3 & 9 into the usual eclipse diagram equation36 (e.g., eq.5) and thus obtain:

\[ \gamma_M = \left( 1 + \frac{\gamma_A}{v_A} \right) \sin \theta_A \approx 60° \text{ or } 51° \]

for \( \gamma_A = 3° \) (eq.4) or \( \gamma_A = 0° \) (eq.6), respectively. Both \( \gamma_M \) are correct within ε.5%. (Moon’s actual mean distance: 60.27. It should be kept in mind that \( \gamma_M \approx 60° \) might already have been independently realized [roughly] by measuring: [a] the slowing of the Moon’s motion near transit, as described here at fn 30; or, [b] rising-vs-setting parallax, as hinted at in [§C1 c].) It is by no means improbable that \( \gamma_M \) was known to within a few Earth-radii in 280 BC — after all, it depends critically (in eq.11) only upon v (or ρ) and ρ; and both of these are easy to find accurately enough for that purpose. (Keep in mind that Aristarchos knew the Moon’s period to a precision that certainly doesn’t sound like a mere “theoretical” math-pedant: [§F9 vs. §A1, fn 20, & fn 34.] In fact, the idea that Aristarchos was so ignorant as to mistake \( \gamma_M \) by a factor of roughly 3 (20’: §C3 & eq.5) — or even a factor as large as 4/3 (80’': Rawlins 1991W eq.31) — is difficult to countenance, since these blunders would require almost impossibly large errors in ρ and (especially) θ.

### D Solar System Scale

D1 We next find what the foregoing implies for solar distance \( r_s \). From eqs. 4 & 11:

\[ r_s = \gamma_M/\sin \gamma_A \approx 60°/\sin 3° \approx 1146° \approx 1000° \]

34 It is possible that pseudo-A was an uninformed hyperpedant (as Neugebauer 1975 p.643 speaks of Aristarchos, believing him to be the author of “Sizes”) — as politically powerful as he was incompetent. Poseidonios is also connected (Neugebauer 1975 pp.654) to \( v = 2 \), perhaps while assuming cylindrical shadow (which ON naïvely relates to null parallax). Did \( v = 2 \) evolve from such mis-geometry?

Alternate route: if a key pseudo-A slip misconstrued \( r_M/r_{E_{\text{ext}}} = 19/11 \) (eq.4 as \( \gamma_M/\gamma_{\text{ext}} = 19/11 \) eq.6), then eq.6 could have produced \( v = 2 \). (Less likely: eq.10 and \( \gamma_M = 19° \) into eq.6) caused \( \rho_6 \) = 1°.)
Aristarchos: Ancient Vision

E Aristarchos & the Seagoat: Expanding the Universe a Trillion Times

E1 The irony is that Aristarchos’ famous Experiment was far inferior\(^1\) to his greatest heliocentrist-scale-contribution. As remarked here at §B1, Aristarchos thought out the implications of heliocentricity to their astonishing and historic conclusion: the absence of naked-eye-visible stellar parallax showed that the stars were at vastly greater distances than geocentrist had realized.

E2 How much greater? Well, according to Archimedes (d. 212 BC), the previous (and still then-current) definition of “universe” was such that its radius was 1 AU. Aristarchos realized that, since the Earth (not the Sun) was moving in a circle of this radius, then: the invisibility of stellar parallax demanded that radius of the Earth-Moon circuit (inferring it as a great or greater than the inverse of the limit of human vision (in radians). From “Aristarchos’ Experiment”, we have already shown independently (§B1) that he used 1/1000 of a radian for that limit. Thus, from eq. 1, he would have set the Sun’s radius relative to the Sun-Earth separation as much as a thousand times greater than the radius of the Earth-Moon circuit.

\( r_{\text{S}} = r_{\text{S}/\mu} = 10000 \text{ AU} \)  

(13)

So it is gratifying to find this result is actually testified to (§B1) as a limiting distance by Archimedes’ “Sand-Reckoner”.\(^2\) But such a scale, though (§E1) much more important than the famous “Aristarchos Experiment”, is far less known today. Exceptions are Heath 1913 (p.348) & Neugebauer 1975 (pp.646&656). But, following the usual misconception that Greeks were non-empirical, neither author considers the possibility suggested here (eqs. 1&13), namely, that this figure was founded upon systematic scientific observations.

E3 Yet it is not difficult to reconstruct the empirical basis. Äetios (a late source) appears to indicate that Aristarchos regarded the stars as suns,\(^3\) saying (Heath 1913 p.305) that he “sets the sun among the fixed stars and holds that the earth moves around the [ecliptic]”. Aristarchos would probably regard stars’ distances as being as randomly varied as their brightnesses.

E4 Thus, the simplest experiment for measuring stellar parallax would be that which was later vainly attempted by W.Herschel (during the project which led him instead to his historic accidental backyard 1781/3/13 discovery of Uranus): look for annual oscillation in the relative positions of false double stars (i.e., two stars which happen quite by chance to be so situated that a line through them passes very nearly through the Solar System), where one of the stars is much nearer the Sun than the other. Some good examples: Giedi, Mizar-Alcor, and Shaula-Lesath. Giedi (the east horn of the SeaGoat, Capricorn) is probably the best example. In the time of Hipparchos, the separation between the Giedi pair \((\alpha^1\text{ and }\alpha^2\text{ Cap})\), respectively was merely 0.5 arcmin: 3.7° in longitude, 3.3° in latitude.\(^4\) The searched-for relative parallactic motion would be almost entirely in longitude. Yet it is certain\(^5\) that no such relative motion was ever observed. An ancient might a priori this by supposing that Giedi’s 2 stars were of similar distance; however, repeated experiments all over the sky would give the same result. Which meant that annual parallax was invisible either from: [i] all stars being at same\(^6\) distance or [ii] stars’ remoteness & thus invisible parallax. The former option would probably be rejected:6 if the seven “planets” were all at different distances, why should thousands of stars all be at only one distance?\(^7\) If Giedi’s nearer star \((\alpha^2\text{ Cap})\)

\[ \text{Archimedes (p.232): Neugebauer 1975 (p.643) calls this his most famous work, even while not realizing its empirical significance.} \]

\[ \text{PlanHyp 1.2.5 has some speculations on celestial bodies’ volumes. Sun a bit larger than the brightest stars, which themselves exceeded all the planets. Jupiter & Saturn were a little smaller, yet still much bigger than Earth.} \]

\[ \text{Notably for a geographic work, Ptolemy had even Mars slightly larger than Earth. (And c.60 times bigger than Venus.)} \]

\[ \text{From the excellent ecliptical tables of K.Moesgaard-L.Kristensen Cennarius 20:129 (1976).} \]

\[ \text{For the Yale BSC parallaxes: for 5α Cap (HR7747) 0.006; for 6α Cap (HR7754) 0.034.} \]

\[ \text{Perhaps to refute arguments such as these considered here, Ptolemy taught that stars were all at one distance (fn 47 PlanHyp 1.2.9. P.B.Goldstein 1967 p.9. Van Helden 1985 p.24), but ancient opinion was not unanimous. (See J.Evans’ new edition of Geminos, or Neugebauer 1975 p.584 n.37a.)} \]

\[ \text{See fn 45 and conclusion of §E3.} \]

\[ \text{Even aside from its Earth-immobility: Ptolemy’s conception had all the stars’ distances the same (Almagest 7.1, Van Helden 1985 p.27), so the Giedi experiment here described would doubly make no impression on him. But one suspects that his demand for uniform stellar distance was designed to defuse (by anticipation) heliocentrist’s potentially troublesome parallactic-questions.} \]
were, say, 1000 AU distant and $\alpha^2$ Cap much$^{48}$ more remote, then, the 2 stars’ relative positions in April vs. October would correspond to baseline 2 AU (see fn 18) — and thus: a total eclipsal parallactic swing of about $2.3438/1000$ or $7^\prime$. As noted above, the eclipsal component of the $5^\circ$ gap (between the 2 stars comprising Giedi) was $3.7^\prime$ in antiquity. But our hypothesis (1000 AU stellar distance for $\alpha^2$ Cap) entails $3.4^\prime$ of eclipsal parallax — which thus predicts the unmissable spectacle of $\alpha^2$ Cap oscillating semi-annually, from eclipsal near-conjunction (October) with $\alpha^1$ Cap, to being (April) distant by an angle equal to c.1/2 the lunar semi-diameter! Obviously, no such effect was observed — and careful ocular monitoring of Giedi and similar star-pairs would have produced an ample supply of null results from the heliocentrist, said null-nurser reservoir would rule out the hypothesis that the stars were merely 1000 AU distant$^{39}$ — and thus supplied the empirical basis underlying ancient heliocentrist’s scientic (not “theoretical”)$^{36}$ conclusion for eq. 13: stars without annual parallax had to be at least another ordmag distant, namely, 10000 AU.

**E5** But we need not speculate on the existence of such observations, since it is obvious from *Almajest* 7.1 (c.160 AD) that, indeed, the ancients had carefully measured lineups and relative positions between stars. And the same source is clear that no such stellar shifts had ever been observed — which is why (until Halley) the stars’ relative positions were regarded as “fixed”.$^{51}$ So the logical conclusion for heliocentric visionaries$^{52}$ would be that the stars were roughly 10000 AU distant (or more), as already expressed in eq. 13.

### F Later Heliocentric Improvements

**F1** There is a hint (Archimedes p.222, Neugebauer 1975 p.646 eq.11) that Aristarchos, ultimately promoted a provocative distance-limit symmetry ($R_T =$ Earth radius):

$$r_S/r_T = R_T = 10000\; \text{AU}$$

This would, if true, represent an abandonment of eq. 12. Regardless of our speculations as to whether Aristarchos himself shifted from eq. 12 to eq. 14 (Archimedes suggests otherwise,$^{53}$ we know (§F2 & eq. 14) that astronomers did so shortly thereafter.

**F2** Kleomedes 2.1 reports (Heath 1913 p.348, Neugebauer 1975 p.656, 1 Kidd 1988 p.445) that Poseidonios (1st century BC) considered the possibility that the Sun was (at least: fn 18) 10000$^\circ$ distant.$^{54}$ This is already given in eq. 14, namely:

$$r_S = 10000^\circ$$

$^{48}$ Apparently dimmer $\alpha^1$ Cap is (fn 44) roughly 6 times more distant than $\alpha^2$ Cap.

$^{53}$ See, e.g., §A1 & fn 20.

$^{57}$ Out of the cases examined this statement entirely with respect to proper motion, but have ignored the parallax question which was of at least equal interest to ancient heliocentrist observers. Geocentrist such as Hipparchos & Ptolemy, who have supplied most of our links to serious ancient astronomy, do not relay discussions of star-shifts in this dangerous parallactic connection.

$^{59}$ Neugebauer 1975 p.657; Pliny!churfermen “grumbled” at nullity of seeking universe’s scale.

$^{51}$ Archimedes (“Sand-Reckoner” p.222) connects Aristarchos to eq. 12, not eq. 15. See fn 32.

$^{63}$ See the precious puzzlement of Toomer 1984 (p.257 n.66 emph added): “There is no point in estimating the relative volumes of the bodies, but it was evidently traditional in Greek astronomy.”

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$^{52}$ See the precious puzzlement of Toomer 1984 (p.257 n.66 emph added): “There is no point in estimating the relative volumes of the bodies, but it was evidently traditional in Greek astronomy.”
F6 We will now show that the superiority of Poseidonios’ conception was probably based on observation, not “naïve” guesswork (Neugebauer 1975 pp.655-656). For solar distance 1146′ (eq. 12), the Sun’s diurnal parallax is 3′. Now, when Mars reaches a station and is roughly near perihelion, it can be less than 0.5 AU from the Earth — which means that a 3′ solar parallax corresponds to about 6′ of Mars parallax. At Alexandria’s latitude, 31°N, while Mars is visible during the night, an observer will be transported well over 1 Earth radius (transversely to the Earth-Mars vector) by the Earth’s axial rotation. So, for $r_M = 1146′$, Mars ought to show ordmag 10′ of diurnal parallactic shift in one night — an angle easily detectable by eye (comparable to the lunar semi-diameter). Meanwhile (as could have been noticed by a transit observer like Timocharis), Mars’ apparent geocentric longitude will vary by merely about half an arcmin over the 48’ period around the station (1st before/after). Such stations must have frequently occurred near enough to stars to make the invisibility of the predicted parallactic shift was repeatedly verified.

F7 There is another planet-star method which requires (not the neat timing of hitting on a station but) a wide geographical range of observations. When Venus is near inferior conjunction, it can be less than 0.3 AU from the Earth. (About 1/3 of an AU at stations.) I.e., Venus’ diurnal parallax can be more than triple the Sun’s. But for 3′ solar parallax (§F6), Venus’ greatest diurnal parallax should be as high as about 10′. If Venus passed near a star, then one need only compare observations taken, say, at Meré (latitude $L = 17°$), vs. ones taken, say, at Byzantion ($L = 41°$). The north-south angular distance between planet & star at conjunction should differ by about 5′ — simply detected by the naked eye.

F8 I propose that our fragmentary record (§F4) of ancient planet-star occultations is part of Aristarchos’ systematic empirical testing — which eventually converted heliocentists, c.270 BC (sometime between Aristarchos’ Experiment & the “Sand-Reckoner”) from 1146′ (eq. 12) to $r_M = 10000°$ (eq. 15). (Such observations, in proving solar remoteness, also proved solar hugeness and thus supported heliocentricity: §F2 & Rawlins 1991P [C3].)

F9 Summing up the evidential situation: we have examined all 3 of the surviving astronomical scales connectable to ancient heliocentists (eqs. 4, 15, & 13); and we have found that each of the 3 is founded on exactly the same empirical base: eq. 1, namely, the correct assumption that the limit of human vision is about $\mu = 1/10000$ of a radian. This present coincidence lends more crediblity to the empirical-base theory proposed here, than most current astronomy-historian archons will ever admit. However, these archons’ own standard myth of the Greeks as mere navel-contemplating theorists has here been revealed as just that: a myth — based upon (implicitly) treating surviving documentation of ancient work as a representative sample. And the slightest common-sense consideration of the long process of filtration of ancient materials (before they reached us) will warn a freshman historian against such naïvete. (Which is spoofed at JHA 11.2 [§A2].) But what can be more than triple the Sun’s? (See Rawlins 1984A p.984, Rawlins 1985K, Rawlins 1985G [§5, Rawlins 1991H fn 1, DIO 11.1-2, DIO 15.1, www.dioi.org/hrh.htm.] DR evidently was the 1st to publish these startling facts, since the Muftia had wilfully overlooked this remarkable achievement. After all, the Muftia has decreed in Science that accuracy is irrelevant to ancient astronomy.

G The Force of Reason and the Force of Prison

G1 We recall O’Gingerich’s suggestion ([A2]) that Aristarchos’ contributions were minor and off-the-top-of-the-head. Thus, Aristarchos’ demotion may be rationalized in the same fashion as the Muftia’s downgrading of the works of creative moderns of whom it disapproves. Gingerich 1985A (p.41): “For better or worse, scientific credit goes generally not so much for the originality of the concept as for the persuasiveness of the arguments. Thus, Aristarchus will undoubtedly continue to be remembered as ‘The Copernicus of Antiquity’, rather than Copernicus as ‘The Aristarchus of the Renaissance’.”

G2 The most obvious problems with these typically anti-revolutionary OG comments (on 2 brave revolutionaries):

[a] To suggest that we slight Aristarchos, merely because attacks on his heresy and on his intellectual freedom succeeded in virtually burying his work — despite his high ancient reputation (Rawlins 1991W [§Q1] & achievements — is effectively to endorse dictatorial bullying & idea-imprisonment. I cannot begin to imagine why the Muftia would sympathize with and effectively endorse such behavior.

[b] Must we follow Neugebauer&OG in letting the brilliance, boldness, & vindication of Aristarchos be lost in the celebrity-spotlight both men shine instead on astrologer-quackery?

— simply detected by the naked eye.
H Heroes & Zeros

H1 Since most great work is the tip of a pyramidal anonymiceberg, it is tricky (& usually unjust) to single out one figure as The Greatest, in any field. However — despite Cleanthes’ worst efforts at grounding him — Aristarchos’ winged mentality soared beyond his terrestrial confines of physical gravity and academic bigotry. And he still glimmers, through the haze of our indistinct record, as the ancient astronomer who perceived, proved, & published the realization that the universe’s record is ordmag a trillion (10^{12}) times larger than hitherto understood, which reveals him to have done even more for our spatial perspective than what 19th century geology & biology did for our temporal vision. His

68 DIO 1.15 fn 24, 16 [HT, §7 §B2].
69 See fn 65. Heath 1913 p.304 (also DIO 1.11 §[3]) recounts Cleanthes’ attempt (paralleling later threats against Galileo) to have a charge of “impriety” brought against Aristarchos — which, in those benighted pagan times, could mean terminal consequences for a career. (Socrates was executed for “impriety.”) Of course, today, as our readers are aware (e.g., DIO 4.3 [15, DIO 6 §3]), we live in an era of free intellectual discourse; for example, even an offense as serious as insufficient brainwashing of histastron archons will have no effect whatever upon a scholar’s career.
70 Neugebauer-Muffia genii discern none of this. Swerdlov 1968 p.96: “There is nothing even approaching a reasonable theory of planetary distances in pre-Ptolemaic literature.” Van Helden 1985 p.9: “Aristarchos’ treatise [‘Sizes’]...addressed only [the Sun & Moon]. No comparable geometric methods...were at hand for determining the sizes and distances of the other heavenly bodies. Indeed, even the order of the planets was a question without a definite answer.”
71 If this seem too strong, see Rawlins 1991P and Thurston 1998A §M5 & 16.
72 Cubing 10000 yields a trillion — and “Sand-Reckoner” (Archimedes p.232) says that Aristarchos’ stellar universe was a trillion times the Earth-orbit sphere, but without explaining the observational base. Geocentrists preferred r_{5}=ordmag 10000 and extant geocentrist schemes (3 are tabulated in Van Helden 1985 pp.27, 30, 32) placed the stars ordmag 10^{2} distant, while Aristarchos-Archimedes held (eq.14) for 10^{12} and 10^{15} distant, respectively; so the net heliocentrist-vs-geocentrist stellar-universe linear expansion factor is ordmag (10000/1000)-(10000/100) ≈ 10000.
73 The tiny universe-scale dominant among geocentrist reminds one of a joke told by Jake Lomota about fellow-pug Rocky Graziano. Both were gifted actors after — and before — their retirement from achievement, among the most extraordinary in the history of human thought, merits more than its fate to now: a mere (largely-uncomprehending) footnote in science history.
H2 The brains (and their retinae & retines), which accomplished this feat, are now dust in the ground — still far from the sky they explored and first comprehended. That dust is even more irrecoverable than the exact details of their original manuscripts, also long gone to dust. But their great discoveries shine on.
H3 For now, this light is darkened and distorted by the turbid, twisted medium of certain modern cultists. (Who do not even appreciate the link between Aristarchos’ work and his vast vision: DIO 4.2 §9) Sadly, “for the indefinite future” (DIO 1.2 §3), intelligent scholars must see past (& calibrate for) the warps created by our grant-begging era, when [a] survival priorities swamp our concern for truth, and [b] power-first businessmen-scholars’ intellectual depth establishes the limit of (public) scholarly debate & consensus.
H4 The modern ironic reality: Aristarchos’ greatness is still being submerged — more than 2000 years after his views’ persecution! — largely because (fn 16) grant-raising via Ptolemy’s fatter extant corpus is still thriving. But that cult’s censorial influence has waned, while among its prime present legacies are G.Toomer’s scrupulous Alm edition, and Toomer’s protégé, the brilliant and creative classicist, Alex Jones, of New York University’s hugely endowed new Institute for the Study of the Ancient World.

Epilog

Because of some (hopefully ever-more-anachronistically) strong critiques in the foregoing, one should understand that it (and other already-published papers on the same subject) evolved over more than 15 years’ (gern published at Rawlins 1991W fn 272), during which much of the Neugebauer clan did what it could to damn the research. But that cult’s censorial influence has waned, while among its prime present legacies are G.Toomer’s scrupulous Alm edition, and Toomer’s protégé, the brilliant and creative classicist, Alex Jones, of New York University’s hugely endowed new Institute for the Study of the Ancient World.

Of course, today, as our readers are aware (e.g., DIO 4.3 [15, DIO 6 §3]), we live in an era of free intellectual discourse; for example, even an offense as serious as insufficient brainwashing of histastron archons will have no effect whatever upon a scholar’s career.
71 If this seem too strong, see Rawlins 1991P and Thurston 1998A §M5 & 16.
72 Cubing 10000 yields a trillion — and “Sand-Reckoner” (Archimedes p.232) says that Aristarchos’ stellar universe was a trillion times the Earth-orbit sphere, but without explaining the observational base. Geocentrists preferred r_{5}=ordmag 10000 and extant geocentrist schemes (3 are tabulated in Van Helden 1985 pp.27, 30, 32) placed the stars ordmag 10^{2} distant, while Aristarchos-Archimedes held (eq.14) for 10^{12} and 10^{15} distant, respectively; so the net heliocentrist-vs-geocentrist stellar-universe linear expansion factor is ordmag (10000/1000)-(10000/100) ≈ 10000.
73 The tiny universe-scale dominant among geocentrist reminds one of a joke told by Jake Lomota about fellow-pug Rocky Graziano. Both were gifted actors after — and before — their retirement from
References

O.Gingerich 1985A. JHA 16:37.
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