Transactions of the American Philological Association 119 (1989) 37–53

FAIL-SAFE STELLAR DATING: FORGOTTEN PHASES

HARALD A. T. REICHE
Massachusetts Institute of Technology

I. Astronomical Background

The coexistence of different ancient calendars[1] reflects the coexistence of different occupations, each with distinct (though, in practice, of course, overlapping) calendric needs. Long-range fiscal planning presupposed the computation of accruals and due-dates; Hellenistic astronomy, that of eclipses and planetary motions. Both tasks, therefore, needed calendars which enabled their practitioners to specify the exact intervals between any two dates, past and/or future. To this end, they devised artificial time-scales whose units (unlike natural months) are absolutely uniform and (unlike the length of the solar year) readily ascertainable. Thus, actual lunar months[2] and solar year were replaced by schematic versions in which twelve 30-day months composed a schematic year of 360 days. Cult and liturgy, on the other hand, tended to be tied to actual lunar months—notoriously non-uniform and collectively incommensurable with one solar year (twelve such months containing only 354 days).

As both the schematic and the lunar calendars fell ever farther behind the natural year, their authors, if only for their own orientation, resorted to occasional intercalation (i.e., repetition) of a month, notwithstanding considerable uncertainty as to the exact solstitial dates. Yet the irregularity and imprecision of such intercalation[3] made the results no more useful to farmers than the original calendars. That was true as much of Mesopotamia as of early Greece with its primitive Octaëteris. For farmers anywhere depend upon continuous, not merely intermittent, contact with the natural year.

It is calendars like that selectively embodied in Hesiod's *Erga* which respond to their real needs. Generically tied to seasonal changes in weather and flora, farming activities typically branched into clusters of related labors. To bear fruit, in the most literal sense of the phrase, each of these, in turn, had to be performed within relatively narrow time-limits and in the right sequence.

[1] Cf. O. Neugebauer, "The Origin of the Egyptian Calendar" (1942), in *Astronomy and History, Selected Essays* (New York 1983) 196–203, esp. 200–201.

[2] This was true in China, India, Mesopotamia, Greece, and Rome (but not in Egypt and Persia). An approximate solar year was approximately subdivided (i.e., to an accuracy of from ±3 days to ±10 days) by means of stellar phases, the exact festival-date being fixed, as it still is in our Easter computation, by reference to the nearest new or full moon following a given stellar phase. Greek reference to the lunar year as κατὰ τὸν θεόν suggests that this supplementary reference to lunations was followed becuase it was thought to represent the gods' own preference, not because it provided convenient grace-periods, like famers' references to later stellar phases.

[3] M. P. Nilsson, *Primitive Time-Reckoning* (Lund 1920) 244–45 and 258 aptly speaks of intercalation by "dead-reckoning" so as to bring, say, cultic calendars into step with the natural phenomena being celebrated (e.g., the Passover date with the ripeness of crops and fruit).

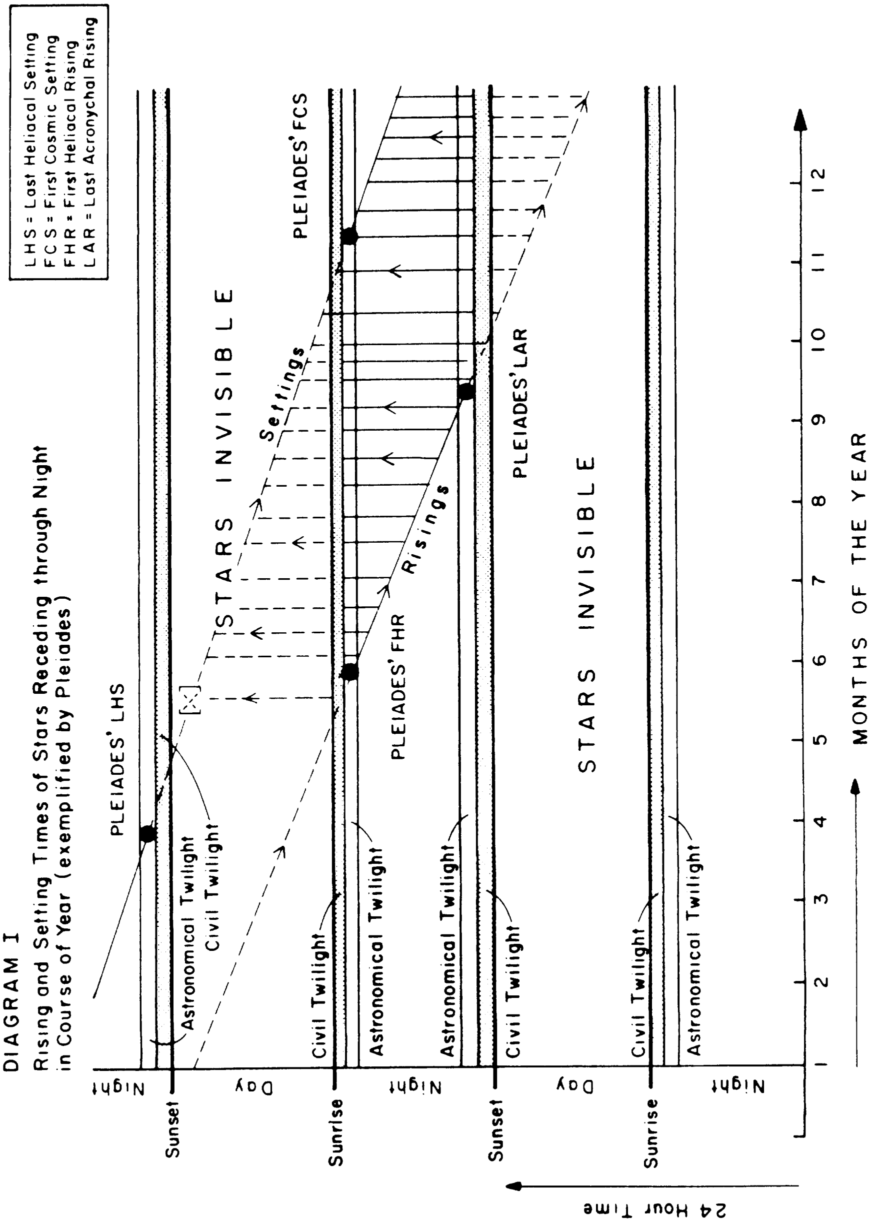


DIAGRAM I
Rising and Setting Times of Stars Receding through Night in Course of Year (exemplified by Pleiades)
LHS = Last Heliacal Setting
FCS = First Cosmic Setting
FHR = First Heliacal Rising
LAR = Last Acronychal Rising
PLEIADES' LHS
PLEIADES' FCS
PLEIADES' FHR
PLEIADES' LAR
STARS INVISIBLE
STARS INVISIBLE
Settings
Risings
Astronomical Twilight
Civil Twilight
Civil Twilight
Astronomical Twilight
Astronomical Twilight
Civil Twilight
Civil Twilight
Astronomical Twilight
Night
Day
Night
Day
Night
Sunset
Sunrise
Sunset
Sunrise
24 Hour Time
1
2
3
4
5
6
7
8
9
10
11
12
MONTHS OF THE YEAR

What is more—a point all too often forgotten—each date had to be preceded and followed by handy periods respectively of early warning and of grace. Now, the resulting number of dates needing to be flagged exceeded that of applicable, i.e., sharply bounded, seasonal changes. Thus, an auxiliary time-scale had to be found whose uneven divisions were smaller than the larger, seasonal, changes in weather, flora, and fauna, but as easily accessible. Only astronomical motions, other than those of moon or sun, could provide such a scale.

For the moon was unsuitable: one lunation is too short; successive lunations, too similar. And the sun was too bright; solstices and equinoxes far too uncertain to support reliable, year-long, day-counts. Appearances to the contrary notwithstanding, Hesiod's two instances of day-counts will be found no exception to this rule.

That left only the fixed stars and constellations which satisfied certain conditions. They had, obviously, to be non-circumpolar. For only then would they rise and set at times which (given the inclination of the sun's annual orbit, the ecliptic, to the equator) were ever earlier relative to sunrise and sunset, and so receded through night and day at the convenient rate of four minutes/day, two hours/month, or 24 hours/year (see Diagrams I, opposite, and II, p. 40).[4]

For example, a given star which is today seen rising before dawn for the first time will, on succeeding nights, be seen to rise at ever earlier hours until, after several months, it will have its last visible rising as it approaches the time of sunset's afterglow. On the very next night, its rising will be outshone by that glow, not to become visible again before dawn (the star's first heliacal rising) till many months later, after receding through all of daytime, sunrise, and dawn. Similarly, the setting times of a given star recede from a first predawn sighting (its first cosmic setting) to a last post-sunset sighting (its last heliacal setting). On the next night, its setting will be outshone by sunset's afterglow, thereafter remaining invisible for many months as it recedes through daytime, sunrise, and dawn, until eventually the star is once again detected setting just before sunrise.[5]

In theory, then, each calendar-star has a total of four annually first and last visible phases: two Morningfirsts (respectively, first heliacal rising and first

[4] Note on Diagrams: (1) For simplicity's sake, the seasonal variations in the relative lengths of day and night have here been neglected. (2) "Civil" and "astronomical" twilight are modern names for the times when the sun is respectively 6 1/2° and 16° vertically below the horizon (cf. P. V. Neugebauer, *Astronomische Chronologie* I [Berlin 1929] 10, 153). (3) Reference in "Abbreviations" (Diagram II, inset) to "Neugebauer's Γ and Ω" is meant to compare and contrast what O. Neugebauer, *The Exact Sciences in Antiguity* (New York 1957) 126–27 calls the "Greek-letter phenomena" of the inner planets. Note that all four of those phenomena are confined to the same horizon as the sun, respectively setting (viz. Ξ and Ω) and rising (viz. Γ and Σ), and thus have nothing to match first cosmic settings and last acronychal risings. Besides, the visibility of inner planets is entirely confined to astronomical twilight (with no preamble or sequel in total darkness) and, as a function of their respective synodic periods, can be quite long. Stellar phases, by contrast, recede through astronomical twilight either into invisibility or total darkness, and for about ten days only.

[5] For full descriptions of the mechanism, see F. K. Ginzel, *Handbuch der mathematischen und technischen Chronologie* I (Leipzig 1906) 23–27; II (ibid. 1911) 309–15; E. Boll, *RE* VI 2 (1909), s.v. "Fixsterne" 2422–29; for brief summaries: D. Dicks, *Early Greek Astronomy To Aristotle* (Ithaca 1970) 12–15; M. L. West, *Hesiod, Works and Days* (Oxford 1978) pp. 379–80.

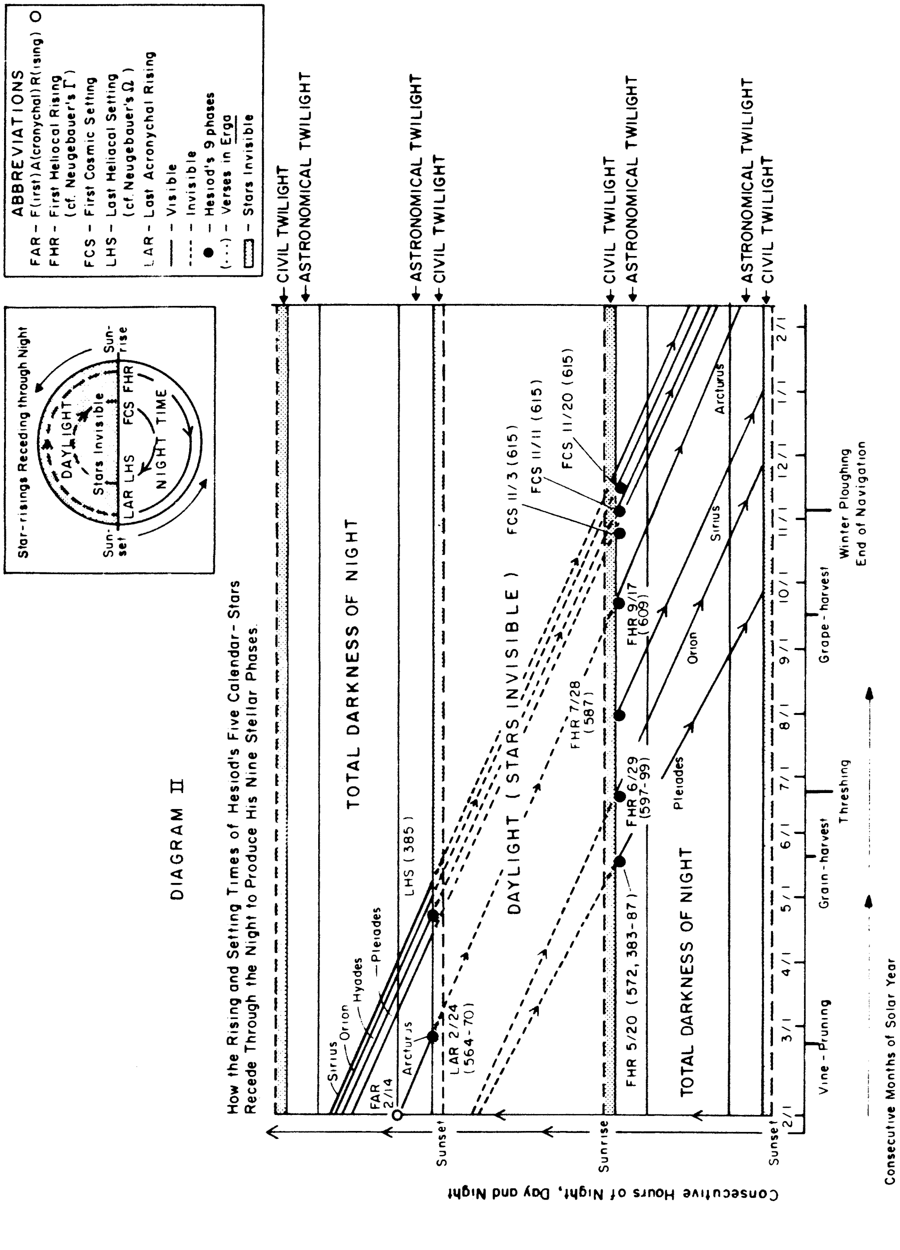


DIAGRAM II

How the Rising and Setting Times of Hesiod's Five Calendar-Stars Recede Through the Night to Produce His Nine Stellar Phases.

cosmic setting) and two Eveninglasts (respectively, last heliacal setting and last acronychal rising).[6] In the practical world of the farmer, however, most of these specifications were dispensed with in favor of a conceptual shorthand. To the farmer, season, labor, and stellar phase constituted a single, triangular aide-mémoire: the mere mention of one of its corners sufficed to evoke the other two and so left little doubt as to what phase was meant. Campaigns being confined to summertime, a comparable aide-mémoire worked for soldiers. Thus, when Thucydides specifies that the Spartans walled Plataea during the "risings" of Arcturus (II.78.2), his point lies in the durative plural, not the fact of the star's (obviously heliacal) rising *per se*. Similarly, Livy's point when explaining the anxiety of Hannibal's troops at a snowfall atop an Alpine pass *occidente iam sidere Vergiliarum* (XXI.35.6) is not the Pleiades' (obviously cosmic) setting *per se* but the durative force implicit in *iam*. Hesiod, too, specifies "rising" or "setting" only for clarity's sake (as at *Erga* 383–87); "after sunset" and "before sunrise," only when seasonally beclouded horizons jeopardize the February and September sightings of Arcturus (*Erga* 567, 610).

To qualify as calendric asterisms for the farmer, moreover, each star or constellation had to be exceptionally bright and/or distinctively shaped. This precluded the zodiacal constellations, successively rising ahead of, or setting after, the sun. Some of these, to be sure, include stars of the requisite brightness and distinctiveness.[7] Yet these qualities are too unevely distributed in the zodiac and out of phase with the dates needing to be flagged to make the zodiac useful *qua* zodiac. Farmers needed asterisms whose first or last risings and settings matched not the relatively abstract solar year, but their concrete and specific labors.[8] Indeed, so close was the match which they needed and found that calendric asterisms and their phases came to be credited with actually causing (ποιεῖν), not merely signalling (σημαίνειν),[9] the seasonal changes in weather, flora, and fauna which guided the farmer (see Diagram II).[10] A farmer's calendar, then, had to have the following characteristics. (1) It had to be built around stellar phases coincident with rustic labors, rather than instantiating some priestly or civil calendar. (2) It needed to cover only the agriculturally active part of the year. (3) It had to be able to rely on direct, visual verification and not require literacy or more than occasional, middle-sized, day-counts (even these preferably in multiples of five days) in order to provide early warnings and grace-periods as well as due-dates. (4) For mnemonic reasons alone it had to be parsimonious. Witness Hesiod's elegant use of nine stellar phases produced by only five different

[6] I am adapting B. L. van der Waerden's terms, Morningfirst and Eveninglast (*Science Awakening* II [New York 1974] 6), so as to include respectively first cosmic settings and last acronychal risings.

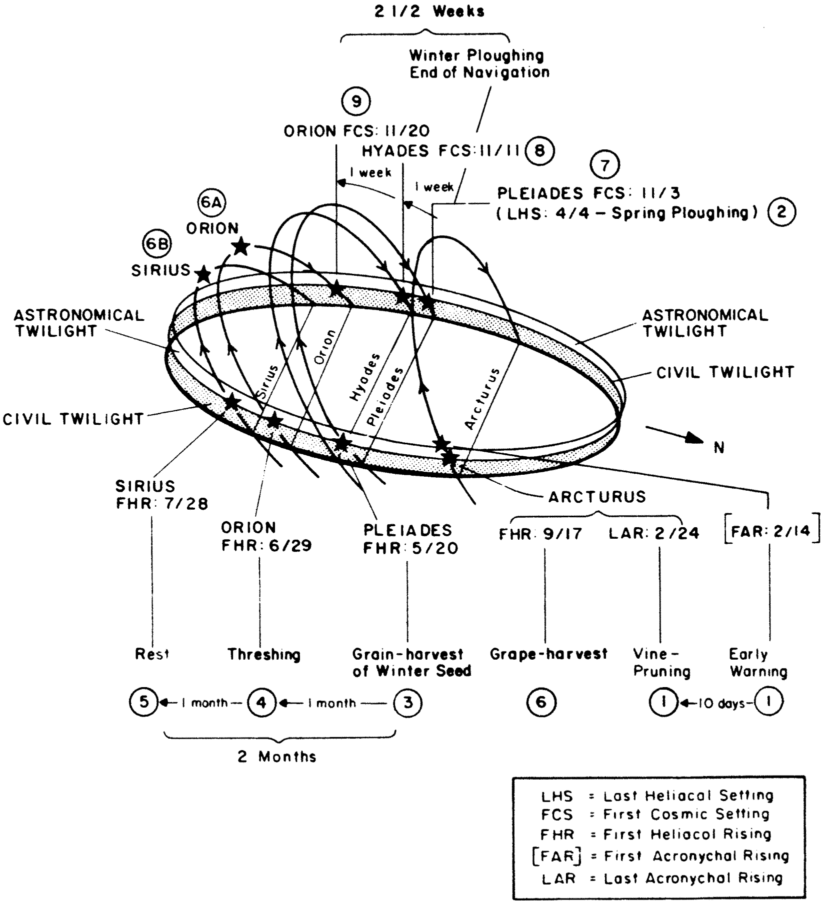
[7] Especially Leo, Taurus, and Scorpius. See W. Hartner, "The Earliest History of the Constellations in the Near East etc.," *JNES* XXIV (1965) 3.

[8] Vergil's language provides neat proof: *quo sidere* (viz. at the first heliacal rising of Arcturus, around autumnal equinox) *terram vertere* (Georg. I.1; cf. 204) and *mutato sidere* (73), instead of at what precise phase, let alone date of a uniform calendar. Cf. Nilsson (above, note 3) 16–17 on *pars pro toto* time-reckoning.

[9] See Boll, *Studien über Claudius Ptolemäus* (Leipzig 1894) 116, 221 n. 1 etc.; Boll (above, note 5) 2431; and finally F. J. Pfeiffer, *Studien zum antiken Sternglauben* (= *Stoicheia* II, Leipzig 1916) 2–12.

[10] This, like the preceding diagram, ignores the changing relative lengths of day and night.

DIAGRAM III
The Spatial Distribution of Successive Rising and Setting Phases Along Horizon



asterisms, all rising and setting at well-known horizon-points,[11] the northernmost and southernmost of these stars (Arcturus and Sirius) being virtually equidistant from the all-important Pleiades (see Diagram III, and below, p. 45).

Yet even if farmers could manage passable day-counts, they could not make practical use of civil calendars, schematic or lunisolar, except to the extent that such calendars included realistic dates of stellar risings and settings. On this score there is clear progress during the 700 years from the Babylonian astrolabes (of c. 1100 B.C.) to the Greek hole-and-peg (*parapêgma*) calendars of Meton (c. 432 B.C.) and his successors. In the earliest astrolabes, three different stellar risings are still found symmetrically distributed over each of twelve schematic months, and with explicit theological sanction at that.[12] By the time of the Babylonian ^{mul}APIN catalogue (c. 700 B.C.), symmetric distribution has yielded to unequal intervals whose empiricism (though tempered by the fact that they are still given in multiples of five days) is attested by the fact that the very start of the schematic calendar is hinged on one particular, empirical, rising.[13] When Meton finally inserts stellar phases into the radically improved lunisolar cycle that bears his name, the calendric needs of farmers at last came into their own, albeit in a form inaccessible to all but a literate minority.[14]

[11] Ginzel I (above, note 5) 26 surmises that heliacal risings must have been still more difficult to spot, since the ancients were unfamiliar with the horizon-points where first risings would occur. This was no doubt true of the risings of zodiacal stars as watched for by laymen. But farmers used a remarkably small number of calendar-stars (see Diagram III). Mediterranean farmers may safely be supposed to have used the sort of local backsight-foresight alignments so well attested for their Northern European counterparts and even American Indians to memorize the horizon-points where Arcturus, Pleiades, Hyades, Orion, and Sirius always effected their annual risings and settings.

[12] Van der Waerden, "Babylonian Astronomy II: The Thirty Six Stars," *JNES* 8 (1949) 10; and *Science Awakening* (above, note 6) 64. The theological sanction is contained in the so-called *Enuma Elish* V 3, "Marduk fixed three asterisms for each (sc. schematic) month of the year." In effect, Marduk thus takes over into his own period of cosmic tenure an older, more perfect order in which sun, moon, and stars still shared in a common 360-day year. Cf. Plutarch, *Is.* 12, 355 D–F for the Egyptian parallel.

[13] Van der Waerden, "Thirty Six Stars," *JNES* 8 (1949) 15; and *Science Awakening* (above, note 6) 74–75.

[14] The same qualification applies to the *Phainomena* of Eudoxus and Aratus and to Vergil. Thus, when having Menalcas describe the decorations on one of his two cups from the hand of Alcimedon, Vergil writes:

> in medio duo signa, Conon et—quis fuit alter,
> descripsit radio totum qui gentibus orbem,
> tempora quae messor, quae curvus arator haberet? (*Ecl.* III.40–42)

The *gentes* for whose benefit Vergil has the (unnamed) Eudoxus construct twelve signs (sc. by halving each of the sides [= the radius] of a regular hexagon) are hardly ordinary farmers. At best they are intellectual farmers or farming intellectuals; more likely, city folk reading about farming. At *Georg.* I.231–58, similarly, Vergil refers to zodiacal signs—as if these had ever been the farmers' primary frame of reference. What W. Ludwig, in a different context, says about Aratus is pertinent here, too: "Damit ist aber auch ausgemacht, dass das Aratische Publikum nicht die gemeinen Bauern und Seefahrer sind, die er in der Fiktion mit gespielter Naivität zu belehren vorgibt, sondern die literarisch gebildeten Kreise

II. Chronological Safety-Nets

Fail-safe datings were a practical need. Our point here is not that what Hellenistic theory was to call "first" and "last" sightings came, and still come, surrounded by a significant margin of uncertainty; rather, that there always existed a very real possibility of missing a phase altogether. Farmers, of course, could not afford to be as generous with their time-specifications as, say, historians. Well might Thucydides, as we have seen, date an event not by "the" (sc. first, predawn) rising of Arcturus but by its plural (i.e., first and subsequent) risings (*epitolas*, II.78.2). Oversight of a first phase was dangerous enough, even though it was bound, in due course, to reveal itself. After all, especially during the cloudy seasons of the year, the realization that one had missed a Morningfirst might come too late for some labor by then long overdue. Oversight of a last phase, however, was potentially fatal: once one had missed it—i.e., failed to notice its non-recurrence on the subsequent night—there would be no further indications that one had done so. Consequently, if grace-periods extending first phases were helpful, early warnings prefacing last phases were indispensable.

The requisite safety-nets could be derived from either non-stellar[15] or stellar phenomena. Here we are concerned with the latter only. Given the universal preference for Morningfirsts, much of our evidence for safety-nets pertains to them. Now the ^{mul}APIN catalogue, roughly contemporary with Hesiod, does not employ grace-periods but only simultaneous phases (e.g., culminations and/or predawn settings) for this purpose.[16] It is in Hesiod (that is, in the tradition he represents) that the use of grace-periods as well as of simultaneous culminations (*Erga* 609–10) comes into its own.

Hesiod primarily relies on calendar-stars which happen to be so aligned with one another that their respective Morningfirsts succeed one another at convenient time-intervals (cf. Diagram III). Thus, in Hesiod's time and place, the predawn risings of the Pleiades, the Hyades, Orion, and Sirius[17] succeeded one another at intervals of about two weeks, two weeks, and one month, combining into an aggregate safety-net of two months. In that context, the first predawn rising of the Hyades could, and probably did, function in two different auxiliary capacities at once. To the prior labor (the grain harvest, keyed to the Pleiades' first heliacal rising) it added a grace-period, even while prefacing the next labor (threshing, keyed to the rising of Orion) with an early warning. Yet Hesiod omits any express reference to the Hyades in connection with the first heliacal risings either of the Pleiades (383, 387, 572)[18] or Orion (598). He mentions the Hyades (615) only in connection with the predawn settings of all but one of

der hellenistischen Städte." ("Die Phainomena ds Arat als hellenistische Dichtung," *Hermes* 91 [1963] 448).

[15] Classic examples of the former are Hesiod's instancing the behavior of cranes, cuckoos, swallows, snails, cicadae, etc., and the blooming of thistle and fig-tree. In fact, at *Erga* 485–90 he expressly cites the grace-period furnished a would-be plougher by the cuckoo's call, once one had missed the traditional date, marked by the swallow's return (*Erga* 568–69), and so found oneself a "late plougher" (*opsarotês*). For a compendium of non-stellar indicators, see Nilsson (above, note 3) 46–47.

[16] Van der Waerden, *Science Awakening* (above, note 6) 77–78.

[17] All but the last are already found on Achilles' shield: *Il.* 18.486.

[18] This marks the *terminus ante quem* for digging up one's vineyard.

the aforementioned asterisms (Sirius' setting goes unmentioned, presumably because practically contemporary with Orion's). Demythologized, the statement that the Pleiades "flee" Orion's (first cosmic) setting (619–20) means that they precede it by two-odd weeks, and that, conversely, the consecutive settings of Hyades and Orion provide that of the Pleiades with a two-tiered grace-period, especially welcome under November's uncertain skies.[19]

Note two points in particular. There is, first, Hesiod's clearly deliberate avoidance of tedium. To keep readers receptive to his larger moral purpose, he eschews those twin-bores, total coverage (e.g., of calendrical matters) and repetitiousness (e.g., of the Hyades' rising and setting between the Pleiades and Orion) in favor of selectivity and *variatio*.

Note, secondly, the economic, indeed elegant, use which the calendric lore sampled by Hesiod makes of a handful of prominent asterisms. The predawn settings of the Pleiades, the Hyades, and Orion (Sirius) crowd into but 17 days, a period only one seventh as long as the four months spanned by their predawn risings. Used in a double capacity, then, the same series of asterisms is made to serve two quite different combinations of needs. With their predawn risings, the asterisms mark three due-dates and two safety-periods; with their predawn settings, only one combined due and termination date and two consecutive safety-periods.

To what extent does Hesiod enlist simple day-counts in the pressing cause of providing chronological safety-nets? In theory, of course, a farmer capable of maintaining a year-long, running day-count could have made use of a star-calendar which (like the one recovered by van der Waerden from ^{mul}APIN) listed the year's consecutive star-risings in the order of their cumulative distances from one initial rising (say, that of Sirius).[20] In practice, however, neither Mesopotamian nor Greek farmers were likely to have either the numerical facility or the practical motive to engage in day-counts, except in a few and relatively short time-contexts calling for an advance notice or grace-period, and in multiples of five or ten. Not surprisingly, all three of the instances of day-counts found in Hesiod's *Erga* conform to this expectation. The Pleiades' (first heliacal) rising, which signals harvesting the winter-seed, is said to conclude "40 days of invisibility" consequent upon their (last heliacal) setting (*Erga* 385–86). Elsewhere, Arcturus' acronychal rise (which signals vine-pruning) is said to occur "60 days after winter solstice" (564–67). Lastly, and depending upon whether we follow Wilamowitz or Evelyn-White,[21] sailing ought either to be deferred till, or to be confined within, "50 days after summer solstice" (663–65).

[19] Orion, the hunter, is himself hunrted, even slain. His first heliacal rising (in late June) is portrayed as the start of an ever more successful escape from Dawn's amorous advances; his first cosmic setting (in late November), as caused by a fatal arrow shot to his head from Artemis' bow. K. O. Müller ("Orion," *RhM* NF 2 [1834] 8) denied any connection between the two portrayals. Yet, if Artemis' bow is the waning moon's last crescent on the opposite horizon, the fact that Orion's first cosmic setting follows (some five months) after his heliacal rising is itself the missing link.

[20] Van der Waerden, "Thirty Six Stars," *JNES* 8 (1949) 19–20; and *Science Awakening* (above, note 6) 75–77.

[21] U. von Wilamowitz-Moellendorff, *Hesiodos Erga* (Berlin 1928) 118 (on line 663); H. G. Evelyn-White, *Hesiod, Homeric Hymns, and Homerica* (Cambridge, Mass. 1936).

III. Uncertainty-Margins

Hesiod states all three of his day-counts in round numbers. His reasons for doing so, however, are not numerological (as often alleged)[22] but eminently practical. Simple rustics naturally emulated Proteus' practice of counting by the five fingers of one hand, and so in multiples of five (πεμπάζειν).[23] Besides, naked-eye sightings of the solstices were much more uncertain than what Hellenistic theory calls "first" and "last" phases. Such phases, notoriously, are subject to an uncertainty-margin of about ±3 days, variables being weather, horizon elevation, keenness of eyesight, practice, and the nature of the phase in question.[24] Ancient pretense to greater precision—whether by Cleostratus (c. 520 B.C.)[25] or the hole-and-peg (παράπηγμα) calendars invented by Meton (c. 432 B.C.) and implied by Varro (see note 26, below), is *prima facie* evidence not of starlit nights spent outdoors watching the sky but rather of white nights spent indoors poring over a celestial globe.

The lay-identification of solstitial dates was more inaccurate still. At Geminus' estimate of ±20 days (VI.29, p. 78.28 M.),[26] the uncertainty surrounding solstices was nearly seven times as great as that surrounding first and last stellar phases.[27] Ostensibly, then, solstitial uncertainty was such as to deprive any day-count based upon them of practical value.

[22] E.g., W. Hartner, *Die Goldhörner von Gallehus* (Wiesbaden 1969) 61 and my review in *Isis* 64 (1973) 236–39.

[23] *Od.* IV 412

[24] On eyesight and atmospheric conditions, see Ptolemy, *Synt.* VIII 6, pp. 203–4 Heiberg = II 91–92 Manitius. To judge by Ginzel I (above, note 5) 26–27 (who cites the astronomer Hartwig) and Dicks (above, note 5) 36–37, modern estimates of the uncertainty-margin fall between ±2 and ±4 days. Schaefer, "Heliacal Rise Phenomena," *JHA* 18 (1987) 19–33 would claim as much as ±7 days for an asterism as relatively dim as the Pleiades.

[25] Cleostratus of Tenedos (*DK* 6 B 1) (520 B.C.) puts the interval between the acronychal rising of Arcturus and the cosmic setting of Scorpius at 83 days.

[26] Geminus is cited from K. Manitius, *Elementa Astronomiae* (Leipzig 1898).

[27] The point bears emphasizing, since the language of three widely used works invites serious misunderstanding, by the unwary reader, of Hesiod's knowledge of solstices (and equinoxes) and might be taken to imply that he made the same use of solar cardinal dates as he did of stellar phases. Thus, Nilsson (above, note 3) 316, "Hesiod is so familiar with the winter and summer solstices that he reckons time from them in days" will presently be seen to be a *non sequitur* (below, pp. 47–48), strangely at variance with his earlier admission (265) that they were difficult to fix. A. Rehm, too, is at least elliptical when writing, "Hesiod benützt sie (sc. die Sonnenwenden) zu genauer Zeitbestimmung" (*RE* [1949] s.v. "Parapegma" 1339). Finally, there is West (above, note 5) 377, "It (sc. the rudimentary 'natural' calendar) was based on observation of the solstices (and to a lesser extent of the equinoxes, which were less easily [*sic*] determined)...." Even Hartner's suggestion (above, note 6) 13 of "an uncertainty of ±8 days or more" is still too generous for the realities of Greek lay-observation. Later on (15) he does admit that the near-perfect concordance, about 4000 B.C., of the heliacal risings of Pleiades, Regulus, Antares, and beta Pegasi with vernal equinox, summer solstice, autumnal equinox, and winter solstice respectively "would necessarily have escaped the early (sc. Mesopotamian) settlers' attention."

The point is indisputable in Hesiod's case. Even if (with Wilamowitz) one were to take *Erga* 561–63 as referring to the vernal equinox, the reference—as he himself and Plutarch saw—is factually so absurd and stylistically so clumsy as to

Take Hesiod's dating Arcturus' postsunset rising to "60 days after winter solstice" (*Erga* 564–67), and the start of safe navigation to "50 days after summer solstice" (663–65). By contrast to the "40 days of invisibility" separating the Pleiades' last heliacal setting from their first heliacal rising (385–87), Hesiod's reference to solstices seems to entail a corresponding increase in the uncertainty—and decrease in the practical usefulness—of the dates being respectively predicted and recommended. Dates so heavily qualified, it seems, would have been of little practical use to winegrowers and would-be navigators. For if sailors found the utility of Hesiod's advice flawed by two sources of uncertainty, his reference to a solstice and by his use of a round number, wine-growers would have found these two sources compounded by yet a third, the familiar ±3 days surrounding the dates of stellar phases.

Tempting though it may seem at first sight, this line of reasoning is in fact unconvincing. One can hardly suppose Hesiod to have included among a host of sound practical counsels two advance notices which poor solstitial dates deprive of any practical utility. Before settling for such an anomaly, one does well to look for a way in which Hesiod's two post-solstitial day-counts could have been practically useful to farmers, notwithstanding the uncertainty surrounding the exact dates of the solstices.

The answer is contained in the nature of that uncertainty itself. For it pertained not to the fact that, twice a year, the sun seems to stand still for some 40 days, but merely to the astronomically exact day within those 40 days when the sun actually does so. Yet, if the apparent 40-day standstills were not in doubt, neither were their beginnings or ends. Either could have furnished farmers with starting-dates no more uncertain than the dates of stellar phases. In practice, of course, it would have been the start, not the end, of the apparent standstills, as indeed Hesiod's two examples confirm.[28]

His advice to defer sailing till "50 days after summer solstice," then, is in fact equivalent to "50 days after the midsummer sun first *appears* to stand still" (a date close to that of Sirius' first heliacal rising). The same explanation, however, goes only part way toward making practical sense of Hesiod's other counsel, where the time to start pruning one's vines is dated to Arcturus' acronychal rising "60 days after winter solstice." For 60 days added to the start of the midwinter sun's apparent standstill (i.e., to an early December date) takes us to a date still some 1 1/2 weeks short of Arcturus' postsunset rising (Ginzel's February 24 date[29] minus three days).

Yet Hesiod's dating is not, therefore, devoid of practical value. Though two weeks short of Arcturus' acronychal rising, 60 days after the apparent start of the sun's midwinter standstill do end on an earlier aspect of the star's postsunset rising perfectly suited to provide a much-needed last warning. The identity of this aspect, and evidence that it was in fact used in the manner here suggested,

traduce itself of non-Hesiodic origin. Recent attempts to salvage the lines (Mazon, Librea, West) seek to rid τετελεσμένον εἰς ἐνιαυτόν / ἰσοῦσθαι νύκτας τε καὶ ἤματα of equinoctial meaning by boldly—probably too boldly—construing ἰσοῦσθαι "keep the (ever shorter) nights in balance with the (ever longer) days (sc. on Time's metaphorical scales) by adding back (sc. in) food-rations (sc. what the nocturnal scale loses in hours)."

28 The same, of course, applies to Varro, one of Vergil's sources. In *De re rustica* I.27–37, pp. 42–49 Goetz, he gives precise day-counts in the form of, e.g., 44 days as the interval between vernal equinox and the Pleiades' (first) heliacal rising.

29 Ginzel II (above, note 5) 310.

are implicit in at least four ancient texts. In the following section, therefore, we shall review the astronomical, the textual, and in particular the Hesiodic evidence favoring the existence and use of this forgotten, preliminary stage. In conclusion, we shall restore it to its rightful place within the multi-tiered safety-net with which Greek farmers surrounded their sightings of first and last calendric stellar phases.

IV. Forgotten Phases

The four canonical stellar phases of Hellenistic theory are two Morningfirsts (respectively heliacal rising and cosmic setting) and two Eveninglasts (respectively heliacal setting and acronychal risting). To become *first* visible, a morning rising (or setting) must have receded through sunrise (or sunset) and the civil twilight preceding it to the very brink of astronomical twilight, i.e., to where the sun's vertical distance below the horizon is at least 6 1/2°. Some ten days later, the star's risings or settings will have receded through astronomical twilight to the very brink of total darkness, i.e., to where the sun's vertical distance below the horizon is no more than 16°. Here then will be the *last* twilight sighting of Morningfirsts. Thereafter, the star's risings or settings will occur in total darkness. Eveninglasts, conversely, are *last* sighted on the border of astronomical and civil twilight, their *first* sighting having occurred ten days earlier, at the transition from total darkness to astronomical twilight. Now Hellenistic theory recognizes as canonical only phases which, in effect, are on the border of civil and astronomical twilight. It officially ignores the *last* twilight sightings of Morningfirsts, and the *first* twilight sightings of Eveninglasts, on the border of astronomical twilight and total darkness, respectively ten days later than Morningfirsts and ten days earlier than Eveninglasts. Yet—and this is the point here being made—each of these latter sightings, though officially ignored, are distinctive enough to provide corresponding ten-day periods either of grace or of early warning.

That they were in fact so employed is suggested not only by two quite untheoretical texts but also, surprisingly, by two instances of Hellenistic theory itself, both in Geminus' *Eisagogê eis ta phainomena* (i.e., *Elementa Astronomiae*, in Manitius' Latinization). In one of these (XII 13, p. 150, 14–18 M.) Geminus speaks of acronychal risings as "first" rather than (as expected) "last": ὅταν δὲ μετὰ τὴν τοῦ ἡλίου δύσιν τὸ πρῶτον (sc. ὁ ἀστήρ) ἐκπεφευγὼς τὰς αὐγὰς τοῦ ἡλίου θεωρθῇ. Manitius' translation shows that he took the passage to mean "But when the star is observed after sunset, upon first escaping the rays of the (sc. setting) sun (i.e., on the border of civil and astronomical twilight), then it is said to have accomplished its visible acronychal rising."[30] To Manitius, the phrase "upon first escaping the rays of the (sc. setting) sun" is astronomically false because it is at variance with the notorious fact that acronychal risings do not move away from but toward sunset-time. Yet, if one translates "when the star is observed after sunset, at a time when initially (τὸ πρῶτον) it has (sc. still) escaped the rays of the (setting) sun (sc. at the star's transition from total darkness to astronomical twilight), then...," Geminus' statement makes good practical—albeit not theoretical—sense. For it is the first twilight sighting of an acronychal rising, at the transition from total darkness to astronomical twilight, which afforded rustics a much-needed ten-days notice of the last such rising soon to follow.

[30] (above, note 26) p. 274 n.

In another passage, Geminus describes a predawn setting as "last" rather than (as expected) "first" (XIII 16, p. 15, 3–5 M.). Here again Manitius would have us suppose either outright error or at least a slip of the pen. He therefore emended τὸ ἔσχατον into τὸ πρῶτον[31], the original reading promptly disappearing into the limbo of scholarly oblivion, never to be heard from again. Here, too, however, the transmitted reading ("last") makes perfect practical sense, provided it is referred not to the time when the predawn setting is first sighted on the border of civil and astronomical twilight, but to the time, ten-odd days later, when the star's last twilight sighting does occur at its transition from astronomical twilight to total darkness, thus providing rustic skywatchers with a welcome grace-period of ten days.

It is at least possible, then, that Geminus' two anomalous descriptions are not the errors which Manitius thinks they are. Possibility hardens to probability when one considers the fact that of Geminus' fifteen departures from astronomical accuracy only nine are indisputable errors (traceable to an ill-trained Constantinopolitan excerptor). Of the remainder, four are mere lapses (omissions and inaccurate generalizations) perfectly compatible with expert authorship. So is prefacing a last by a first acronychal rising, or appending a last to a first cosmic setting (as evidence derived from two agricultural authors will presently be found to render highly probable). Suffice it here to suggest that Geminus' two anomalous descriptions, too, are lapses rather than outright errors. In largely agricultural societies, after all, most people—intellectuals included—grew up in close contact with all manner of farmers' practices, not excluding their ancient ways of securing the stellar dates essential to their annual round of labors. Small wonder, then, that the mere mention of a stellar phase could evoke a train of fixed and instant associations such as, in a moment of absentmindedness, could easily bypass even a theoreticians's conscious controls.

V. The Evidence of Agricultural Authors

In *Erga* 564–67 Hesiod fixes the date when to start pruning one's vines (570) by reference to the (or rather: an) acronychal rising of Arcturus. Here are text and (Evelyn-White's LCL) translation:

> Εὖτ' ἂν δ' ἑξήκοντα μετὰ τροπὰς ἠελίοιο
> χειμέρι' ἐκτελέσῃ Ζεὺς ἤματα, δή ῥα τότ' ἀστὴρ
> Ἀρκτοῦρος προλιπὼν ἱερὸν ῥόον Ὠκεανοῖο
> πρῶτον παμφαίνων ἐπιτέλλεται ἀκροκνέφαιος.
>
> "When Zeus has finished 60 wintry days
> after the solstice, then the star
> Arcuturs leaves the holy stream of Ocean
> and first rises brilliantly at dusk."

When 60 days after winter solstice, so Hesiod says, Arcturus first rises "at the start of darkness" (ἀκροκνέφαιος) etc. The passage contains two major difficulties. First, as we have already seen (above, pp. 45–46), this ostensibly so straightforward time-indication (or, rather, long-term advance notice) contains no fewer than three uncertainty-factors.

[31] See apparatus ad loc.

A stellar phase, subject to an uncertainty-margin of ±3 days, is linked to a prior solstice subject to an uncertainty-margin of ±20 days, by means of a day-count that is evidently rounded off. Now for a post-solstitial day-count to be of practical use to farmers, we found that its beginning would have to coincide with that of the apparent standstill, i.e., with a date some twenty days prior to the true (but unknown) solstitial one. If so, however, Hesiod's "60 days after winter solstice" would still fall short by some ten days of the ±3 days surrounding Arcuturus' last acronychal rising. Our first question, then, is whether this shortfall does not deprive Hesiod's prescription of practical usefulness, after all.

The second major difficulty concerns the precise meaning to be attached to the oddly emphatic temporal adverb, "first" (πρῶτον), which opens line 567. Emphatic because opening position strongly reinforces the emphasis already inherent in πρῶτον by virtue of its metrical value, the resulting emphasis extending through παμφαίνων, i.e., almost to the middle of the line. One solution will be found to resolve both difficulties at once.

The latter difficulty, of course, derives from the fact that what on the canonical view should be a last acronychal rising is here labelled "first." Scholarly attempts to find an explanation of πρῶτον which removes the difficulty are legion. Those sensible to πρῶτον's special emphasis have sought to account for it in one of two ways. Some have imputed to Hesiod a simple lapse from astronomical accuracy.[32] Yet they forget that pretheoretical astronomy never specifies that a given calendric phase is first or last. Others avoid blaming Hesiod by taking παμφαίνων either in the (unattested) sense of "shining all night long"[33] or as reflecting what they (mistakenly) take to be a star's greater brightness near the horizon than when higher.[34] Still others try to have it both ways. They concede the special emphasis vested in πρῶτον but dismiss it as insignificant on the ground of the scholia's silence.[35] Others, finally do not even concede that special emphasis. Instead, they refer this "first," like the other five found in *Works and Days*, to the year as a whole, taking it to mean, in effect, "when first in (or: as soon as in the course of) the year."[36]

[32] So J. L. Ideler, *Handbuch der mathematischen und technischen Chronologie* I (Berlin 1825) 246 n. 5. He adds, "Solche Verwechslungen kommen auch anderwärts vor."

[33] A. Waltz, *Hésiode* (Bruxelles 1909) 88 (on 567), "Des astronomes modernes ont calculé qu'Arcture devait être visible toute la nuit (παμφαίνων) en Béotie au début du VIII^{e} avant J–C, à partir du 27 Février, soit 58 jours après le solstice d'hiver."

[34] So, oddly, Housman in a letter to Ernest Harrison (= *The Letters of AEH*, ed. H. Maas [Cambridge, Mass., 1971] 420). *Contra*: e.g., Hawkins, *Stonehenge Decoded* (London 1966) 229, "But a star, as viewed at sea level under even the best conditions, is less bright by at least six magnitudes than it is when viewed higher in the sky." As for the rest, Housman writes, "I should say...that πρῶτον signifies simply emergence into sight (προλιπὼν ῥόον Ὠκεανοῖο) and does not conflict with the fact that an ἐπιτολὴ ἑσπερία is a last and not a first appearance." But that is simply tantamount to not acknowledging either the adverb's special emphasis or the need for an early warning.

[35] E.g., C. Goettling and J. Flach, *Hesiodi Carmina*³ (Leipzig 1878) 252 (on 567). After citing Ideler's view (above, note 31), they add, "Mirum tamen si ita confudit cana antiquitas. Potius ita voluisse videtur poeta: προλιπὼν πρῶτον ἱερὸν ῥόον κτλ."

[36] E.g., W. Marg, *Hesiod* (Zurich 1970) 362. West (above, note 5) 299 gives merely a cross-reference to "387 (sc. τὰ πρῶτα with φαίνονται, cf. 567, 598)."

Yet though this conventional "first in the year" is clearly copresent in the πρῶτον of 567, it is unlikely to be its sole meaning, and for four reasons: the special emphasis vested in πρῶτον; the un-Hesiodic awkwardness of writing "when first Arcturus (sc. last) rises acronychally"; the practical need for short-term early warnings; and the inaccuracy of (WS+60 days).

All four difficulties disappear, however, if we take this πρῶτον to refer not to the last but to the first postsunset twilight rising of the star, i.e., to the time some ten days prior to its last acronychal rising. The star is then quite literally "first" in two senses. One is the conventional, annual, sense. The other, however, which accounts for the special emphasis upon this πρῶτον, refers to the twilight following sunset. "First" in that sense means "at the star's transition from total darkness to astronomical twilight" (see Diagram IV, p. 52)—precisely the point of Geminus XII 13 (see above, pp. 48–49).

The adjective used by Hesiod to designate Arcturus' acronychal rising is *akroknephaios*, "at the tip, or beginning, of (sc. total) darkness." Its exact Latin equivalent in Columella (describing the same phase of the same star) is *prima nocte oritur* (*De re rustica* II 2.1). Both agricultural writers thus replace what, in terms of the star-rising's long-term regression, ought to be called "at the tip, or beginning, of astronomical twilight" by the more vivid, because diurnally palpable, "at the tip, or beginning, of total darkness."[37] They describe an Eveninglast's chronological recession from total darkness to astronomical twilight in terms of nightfall's progression in the opposite sense, i.e., from astronomical twilight to total darkness.

VI. Summary and Conclusions

Marginal by modern standards, ancient farming was ever vulnerable to crop-failure and all its consequences—hunger, debt, servitude. Farmers were correspondingly anxious not to miss those first and last stellar phases to which their labors were so closely keyed. They therefore prefaced, accompanied, and followed those phases with auxiliary indicators, astronomical as well as non-astronomical. Of astronomical indicators there were two kinds, those external and those internal to a particular stellar phase being secured. The external sort is, on the whole, well understood. It includes phenomena conventionally, if inaccurately, labelled παρανατέλλοντα, i.e., concurrent with and either prior or subsequent to a particular phase.[38] We have seen how corollary day-counts, when based on a solstitial date, could in practice be immunized against the gross uncertainty surrounding those dates. But it is the second class of auxiliary indicators whose identity and rehabilitation form the central subject of the present paper. These are the indicators internal to the particular stellar phases to be secured.

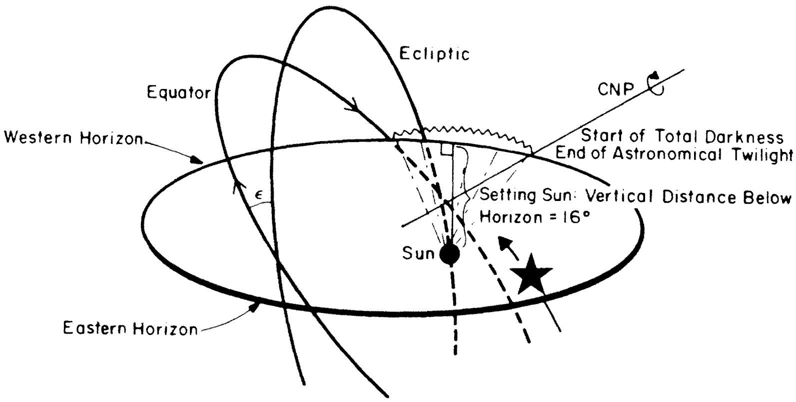
This ignores the crucial distinction, here at issue, between "first within a given series of Morningfirsts" (unattested before Hellenistic theory) and "first within the agricultural year," as in 387, where it also refers to the sharpening of one's sickle.

[37] Thus, too, περὶ πρῶτον ὕπνον (*concubia nocte*) unequivocally refers to the time around midnight as counted in its diurnal (sunset to midnight) sense: Cf. H. L. Ahrens, "Zu Aeschylus Agamemnon," *Philol. Suppl.* I (1860) 570 and Fraenkel on Aeschylus, *Ag.* 826 (v. II 380–81).

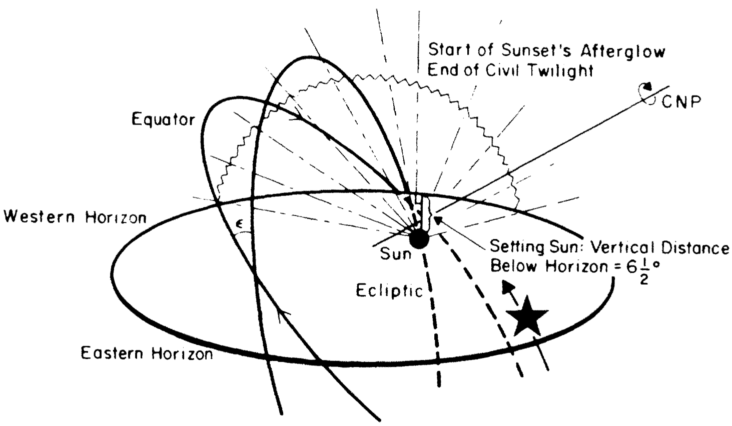
[38] Cf. Boll, *Sphaera* (Leipzig 1903) 88; H. Gundel, *RE* XVIII 3 (1949), s.v. "Paranatellonta" 1215.

DIAGRAM IV

(I) Arcturus' <u>First</u> Acronychal Rising
(about February 14)



(II) Arcturus' <u>Last</u> Acronychal Rising
(about February 24)



CNP = Celestial North Pole

While the two canonical Morningfirsts, respectively first heliacal rising and first cosmic setting, of a given calendar-star are sighted at the transition from civil to astronomical twilight, the same star will be observed rising or setting ten days later at the very end of twilight, i.e., at the transition from astronomical twilight to total darkness. Effectively a Morninglast, it will then be able to furnish the two canonical Morningfirsts with corresponding grace-periods. Conversely, while the two canonical Eveninglasts, last heliacal setting and last acronychal rising, of a given star are sighted at the transition from astronomical to civil twilight, the same star will already have been seen to set or rise ten days earlier at the very start of twilight, i.e., at the transition from total darkness to astronomical twilight. Effectively an Eveningfirst, it will then be able to preface the two canonical Eveninglasts with corresponding early warnings.

Of the four auxiliary phases thus inferred only two are documentable so far. They are respectively a first (prefacing a last) acronychal rising and a last (following upon a first) cosmic setting. Of these two, the first is virtually certain, being buttressed by the combined testimony of Geminus, Hesiod, and Columella; the second, probable though as yet supported by a theoretical passage only. One thing, however, is clear already. These ancient, eminently practical, auxiliary sightings survived as a sort of fossilized reflex inside the heads and hurrying pens of the very theoreticians who would never, except in a fit of absentmindedness, have dignified them with theoretical status.