Is an eclipse described in the Odyssey?

Constantino Baikouzis*† and Marcelo O. Magnasco*‡

*Laboratory of Mathematical Physics, The Rockefeller University, New York, NY 10065; and †Proyecto Observatorio, Secretaría de Extensión, Observatorio Astronómico de La Plata, Paseo del Bosque, B1900FWA La Plata, Argentina

Communicated by Mitchell J. Feigenbaum, The Rockefeller University, New York, NY, April 7, 2008 (received for review July 2, 2007)

Plutarch and Heraclitus believed a certain passage in the 20th book of the Odyssey (''Theoclymenus's prophecy'') to be a poetic description of a total solar eclipse. In the late 1920s, Schoch and Neugebauer computed that the solar eclipse of 16 April 1178 B.C.E. was total over the Ionian Islands and was the only suitable eclipse in more than a century to agree with classical estimates of the decade-earlier sack of Troy around 1192–1184 B.C.E. However, much skepticism remains about whether the verses refer to this, or any, eclipse. To contribute to the issue independently of the disputed eclipse reference, we analyze other astronomical references in the Epic, without assuming the existence of an eclipse, and search for dates matching the astronomical phenomena we believe they describe. We use three overt astronomical references in the epic: to Boötes and the Pleiades, Venus, and the New Moon; we supplement them with a conjectural identification of Hermes's trip to Ogygia as relating to the motion of planet Mercury. Performing an exhaustive search of all possible dates in the span 1250–1115 B.C., we looked to match these phenomena in the order and manner that the text describes. In that period, a single date closely matches our references: 16 April 1178 B.C.E. We speculate that these references, plus the disputed eclipse reference, may refer to that specific eclipse.

astronomy | history | Homer

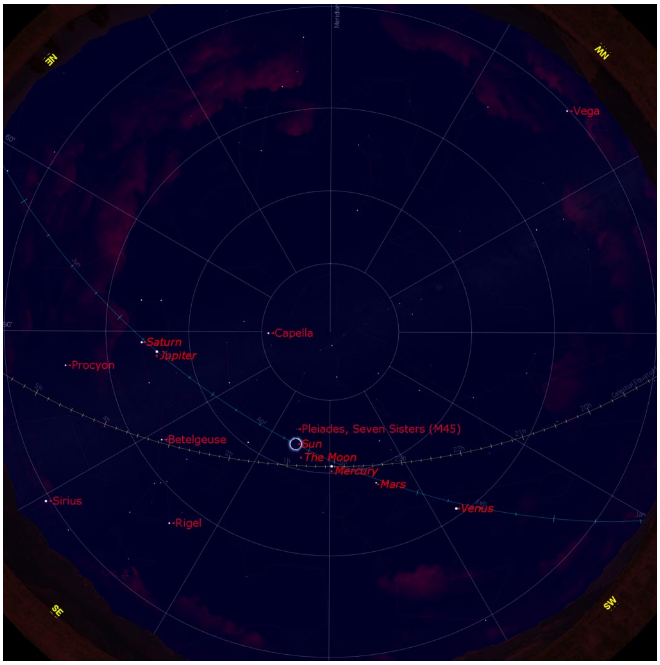

Fig. 1. The total solar eclipse of 16 April 1178 B.C. (the 31st eclipse in Saros Series 39) seen from the Ionian Islands at 12:02 p.m. local time. This eclipse was spectacular: all planets were visible simultaneously on a 90° arc on the ecliptic; the hidden sun was ''crowned'' by the Pleiades. Apparent magnitudes: Venus, −4; Jupiter, −1.9; Mercury, −1.2; Saturn, 0.16; Mars, 1.3.

> "Now when did Odysseus return to Penelope? The date is given with a precision most unusual in epic poetry."
> Gilbert Murray, *The Rise of the Greek Epic*

On 16 April 1178 B.C., close to noon local time, the total eclipse of the sun depicted in Fig. 1 occurred over the Ionian Sea (1, 2). It was early spring because the equinox had occurred on 1 April. The eclipse was spectacular: On an arc on the ecliptic of <90°, the five "naked eye" planets, the moon, and the sun's corona could be seen simultaneously. Total solar eclipses are rather rare, occurring approximately once in 370 years at any given location on the planet (3). During a solar eclipse, our visual system adapts to the slow change in overall illumination so that no change is at first perceived: A few seconds before totality, the Sun is still a million times brighter than a full Moon. At totality, the Sun appears to be dramatically and suddenly extinguished (4, 5); the sky does not turn red but rather ink blue as in late twilight, and then stars appear. Temperatures drop suddenly a few degrees, winds change, animals become restless, and human faces may have a striking exsanguinated appearance in the bluish light. The effect can be rather ghoulish, a reason eclipses were considered ill omens.

In the 20th book of the Odyssey, as the suitors are sitting down for their noontime meal, Athena "confounds their minds" (Od. xx.345) so that they start laughing uncontrollably and see their food spattered with blood. Then, the seer Theoclymenus makes a most remarkable speech foreseeing the death of the suitors and their entrance into Hades, ending in the phrase (xx.356) "ἠέλιος δὲ οὐρανοῦ ἐξαπόλωλε, κακὴ δ' ἐπιδέδρομεν ἀχλύς": "The Sun has been obliterated from the sky, and an unlucky darkness invades the world." The word that we have translated as "invades," "ἐπιδέδρομεν," had a connotation of "attacking suddenly or by surprise," the modus operandi of an eclipse; "κακὴ," often translated as "evil" in this passage, also meant "unlucky" when referring specifically to omens. Plutarch, who himself made multiple descriptions of eclipses (6), suggested that this was a poetic description of a total solar eclipse (7, 8), a theory also developed by Heraclitus the Allegorist (9); both note several references to the day being New Moon, a necessary condition for a solar eclipse. This conjecture has not been widely accepted because there is no explicit mention of an eclipse elsewhere, the passage takes place indoors, no other characters appear to see an eclipse, and the darkness described in the passage agrees with imagery of Hades. Because Theoclymenus's only purpose appears to be the uttering of that specific speech, some authors consider the lines themselves suspect (10). In this light, the notion that the passage could refer not just to an allegorical eclipse used by the poet for literary effect but actually to a specific historical one (11), such as the 16 April 1178 B.C. eclipse proposed by Schoch (1, 12, 13) and Neugebauer (14), seems unlikely because it would entail the transmission through oral tradition of information about an eclipse occurring maybe five centuries before the poem was cast in the form we know today. Furthermore, there are inexactitudes

---

Author contributions: C.B. and M.O.M. designed research, performed research, analyzed data, and wrote the paper.

The authors declare no conflict of interest.

‡To whom correspondence should be addressed at: Box 212, 1230 York Avenue, New York, NY 10065. E-mail: magnasco@rockefeller.edu.

This article contains supporting information online at www.pnas.org/cgi/content/full/0803317105/DCSupplemental.

www.pnas.org/cgi/doi/10.1073/pnas.0803317105

Table 1. Chronology of the Odyssey

Day, sequential	Day, parallel	Action	Lines
−40	−33	Council of the Gods. Poseidon in Ethiopia. Athena goes to Telemachus.	
−39	−32	Ithaca assembly. Telemachus starts for Pylos.	
−34	**−33**	**Council of the Gods. Zeus sends Hermes to Ogygia.**	
		Calypso tells Odysseus he can go.	**v.1–v.261**
−33 to −30	−32 to −29	Odysseus builds his raft	v.262
−29	**−28**	**Calypso sends Odysseus off at sunset, telling him to watch Pleiades and Boötes and keep the Bear left.**	**v.263–v.278**
−28 to −12	−27 to −11	Spent Sailing.	v.279
−11	**−10**	**After returning from Ethiopia Poseidon Earthshaker sees Odysseus and sinks his raft.**	**v.280–v.387**
−10	−9	Spent swimming.	v.388–v.389
−9	−8	Odysseus arrives in Phaecia and sleeps on dry leaves.	v.390–v.493
−8	−7	Meets Nausicaa. Goes to Alcynoos's.	vi.1–vii.347
−7	−6	In Alcynoos's palace. Games. Narrates the Odyssey.	viii.1–xiii.16
−6	−5	After gifts, beach party. Odysseus boards ship at sunset.	xiii.17–xiii.92
−5	**−4**	**Odysseus arrives in Ithaca with the Star of Dawn. Meets Athena, dines with Eumeus.**	**xiii.93–xiv.533**
−4	−4	Athena fetches Telemachus; he sleeps at Phera.	xv.1–xv.190
−3	−3	Telemachus spends the day traveling back to Ithaca.	xv.191–xv.302
		Odysseus dines with Eumeus, who tells his story.	xv.303–xv.493
−2	−2	Telemachus arrives at dawn in Ithaca foiling suitors, straight to Eumeus's, meets Odysseus.	xvi.1–xvi.478
−1	−1	Odysseus enters his halls. Argos. Talks to Penelope. Discovered by Euriclea.	xvii.1–xx.54/90
0	*0*	*Festival Day of Apollo. Eclipse. Death of Suitors. Meets Penelope.*	*xx.91–xxiii.344*
1	1	Meets Laertes. Battles people, Athena stops it.	xxiii.345–

This table enumerates the days elapsed in the Odyssey, numbering as Day 0 the death of the suitors. Epic tradition requires that events that are simultaneous be narrated as though they were consecutive (13), and the Odyssey follows this format. However, not knowing whether we should consider them consecutive for astronomical purposes, we retain two alternative numberings: The first column enumerates days using consecutive reckoning (e.g., the day Odysseus lands in Ithaca and the day Athena tells Telemachus to return from Sparta are consecutive days), whereas the second uses the parallel reckoning (i.e., Athena arrives in Sparta instantaneously rather than a day later). Because Odysseus departs Ogygia close to sunset and lands in Scheria before sunset, he spends exactly 20 days and 20 nights at sea.

involved in tracking eclipses in antiquity, because the earliest verified eclipse records are in the 8th century B.C.; extrapolation to earlier times involves errors that increase quadratically with time before the earliest records, and that for this eclipse could be ≈2–3°, approximately the width of the track itself [see supporting information (SI) Fig. S1]. Therefore, even though statements like "a solar eclipse may mark the return of Odysseus" are widely quoted in books and web sites on eclipses (3, 5, 15, 16), most Homeric scholars do not give much credence to this notion: The authors were unable to find a single translation of the Odyssey mentioning an eclipse in a footnote to xx.356.

Because the lines describing the alleged eclipse are considered suspect, we shall use other passages in the Odyssey to shed some light on the issue, without assuming an eclipse. Given an interpretation of certain passages in the Odyssey as describing astronomical phenomena, we will look for dates in which the phenomena match. We shall find that the most likely day matching these other phenomena is 16 April 1178 B.C., suggesting there may be corroborating information in the epic for the eclipse hypothesis. In other words, the passages we analyze appear to cohere. Two important caveats: first, that if our interpretation of such passages as astronomical phenomena were incorrect, our calculation of dates and their probability or improbability would also be incorrect; and second, that even if correct, we get no indication whether the events narrated in the epic did happen.

Method

Table 1 shows the chronology of events in the Odyssey and the numbering of days used henceforth, with an explanation of sequential and parallel chronologies; a full listing of referenced passages and line numbers is in Table S1. The overt astronomical references in the Odyssey are few, yet significant. As Odysseus sets out from the island of Ogygia on the evening of Day −29 (v.270–277), he navigates by the stars as instructed by Calypso, watching the Pleiades and late-setting Boötes, and keeping the Great Bear to his left. [A few of these exact same lines appear in the Iliad (Il. xviii.485).] Later, as the Phaetians give him passage, they see Venus just before arriving in Phorcys's Bay before dawn on Day −5 (xiii.93–96). Several passages note the night before the massacre of the suitors and the presumed eclipse is New Moon: Odysseus himself, disguised as a beggar, declares first to Eumeus (xiv.161) and then to Penelope (xix.306) that Odysseus shall arrive after the passing of this Moon and the beginning of the new one; Night −2 is dark and moonless (xiv.457). Because Day 0 is also stated multiple times to be the festival day of Apollo, a solar deity, there has been some speculation that the conjunction of a lunar and a solar period marks the end of a Metonic cycle (17, 18). We shall supplement these three overt references with a more conjectural one. There are two significant voyages of Gods (19) that appear precisely once in the epic. First, Hermes travels far west to Ogygia, makes a long-winded protestation about the length of his trip (v.55, v.97–103), delivers his information, and immediately travels back east. We shall interpret this trip as an allusion to a planetary motion of Mercury. Although this interpretation is fraught with uncertainty, we shall try our best to support it below; and although it remains conjectural, we shall assume it as a hypothesis and see where it leads us. Second, at the outset, Poseidon is "in the land of the Ethiopians"; immediately after returning, he sees Odysseus on his raft and sinks him (v.282). This has been conjectured to be an allusion to the Equinox (34); we shall not assume this conjecture, although we will bear it in mind.

To search for a potential date satisfying the references, we shall use the following strategy. The classical estimates for the date of the fall of Troy are (in years B.C.): 1135 (Ephorus), 1172 (Solsibus), 1184 (Eratosthenes), 1193 (Plato), 1208 (Parian chronicles) 1212 (Dicaearchus), ≈1250 (Herodotus) and 1333 (Douris); in addition, the most likely candidate for Homeric Troy is Troy VIIa, whose destruction layer has been dated to ≈1190 B.C. Neglecting Douris's estimate, separated from the others by the largest margin, this gives a range of 1240–1125 B.C. for Odysseus's return to Ithaka. These dates are modern interpretations and subject to uncertainty in ancient chronologies, so we shall extend the range by 10 years in both directions, to search in the range 1250–1115 B.C.

As Day 0 is a New Moon, we enumerate all 1684 New Moons in the range 1250–1115 B.C.; call the date of each T_i. We shall then require that on $T_i - 29$ the constellations be seen as described, that on $T_i - 5$ Venus be high in the sky before Dawn, that on $T_i - 34$ Mercury be far to the west, as detailed below.

There are numerous caveats that should be borne in mind. Many long-term trends need to be accurately estimated to obtain the position of stars and planets in historical periods: the precession of the axis of the earth, proper motion of the stars, accurate orbital parameters for planets and moons, and a good fit to the braking action of the tides on Earth (20), for which verified historical records of eclipses have been instrumental (2, 16, 21–30). Similarly, star and planetary visibility require an understanding of the refracting nature of the atmosphere close to the horizon, and the different visibility of a dim star or planet after sunset or before sunrise, depending on whether it lies on the same or the opposite side of the horizon as the Sun. These calculations are now implemented in commercial as well as open source astronomical software. Emphasizing that this exploration is available to any enthusiast, our calculations were done with off-the-shelf software; we used Starry Night Pro as our general planetarium software [ref. 31; plots presented in this article were produced by using Starry Night Pro, which uses VSOP87 for planetary positions and Chapront's ELP-2000/82 for the Moon's position, and computes ΔT adjustments according to Meeus following Stephenson and Morrison (1984) with additional adjustments; ΔT for our eclipse is 27,602.7 sec], EmapWin for maps of eclipse tracks [custom-corrected for the latest ΔT revisions from Espenak (2)], and Planetary, Lunar, and Stellar Visibility version 3.0 (32) for atmospheric extinction calculations of visibility phenomena. In the latter, we use its standard magnitude-corrected parameters for visibility phenomena, assuming a minimum height of 1° for visibility of Mercury and 2° for the Pleiades. We remind the reader that dates of first and last visibility are not astronomical but rather psychophysical phenomena influenced by weather, and should always be assumed to have an uncertainty of at least a day. All dates shall be in the Julian calendar, all times local to the Greek islands, and all seasonal references affected by Julian date creep and equinox precession refer to the 12th Century B.C.E.

References and Constraints

Day 0 is stated, several times, to be a New Moon, and hence our search strategy will search only on New Moons. One moon before, at sunset on Day −29, Odysseus sets sail from Ogygia, and "sleep did not weigh on his eyelids as he watched the Pleiades, and late-setting Boötes, and the Bear" which (being circumpolar at that time) would not set. The Bear reference informs us Odysseus is sailing due east, since he must keep it to his left. The role of Boötes and the Pleiades is subtler: constellations set at different hours in different seasons, and because the Pleiades and Boötes are far apart in the sky, their simultaneous appearance is not a given. This passage thus states the time of the year that the travel takes place, in a form that may have been transparent to many at the time the epic was cast in written form: These particular stars were used for keeping track of the seasons for agricultural purposes [see, e.g., Hesiod (33) and *SI Discussion*]. There are two times in the year when both Pleiades and Boötes are visible together for some time after twilight: around March, as the Sun approaches the Pleiades, these set early while Boötes sets late; in September, it is Boötes that sets early while the Pleiades set late. Because the passage is quite unambiguous (Odysseus watched the Pleiades, and Boötes that sets late, and the Bear that never sets) we shall take it to mean literally what it says. March sailing was supported in a lucid short paper by T. L. MacDonald (34), who argued that for the passage to make sense, "the Pleiades might have helped [Odysseus] retain the direction of sunset as twilight faded and late- or slowly-setting Arcturus helped him to judge the opposite direction of sunrise while he kept the Bear on his left." At nautical twilight, when the sun has sunk 12° below the horizon and stars useful for navigation become visible, the earliest in the year that Boötes would be visible (its apparent achronical rising) was 17 February, while the latest night that the Pleiades would be visible was 3 April. Hence, $T_i - 29$ should be between 17 February and 4 April. In fact, as Odysseus navigates by these stars every night until sunk, the entire period of 17 days he sailed before being sunk should be contained in the interval 17 February to 4 April. One or at most two moons T_i each year satisfy this criterion, so we discard all others. Other indications in the Odyssey are consistent with the late winter–early spring timeline: There are numerous references to the nights being long, fires, and coats throughout the poem, yet when Odysseus first meets Eumeus he claims to have hidden in a wood under "much-blossoming" forest-trees (xiv.353). At the opening of the poem, it is said that the year was drawing to a close, and Hesiod thought the year to end in the vernal equinox (*SI Discussion*). Perhaps this reference was not meant to be obscure, because much of Homer's contemporary audience[¶] would be familiar with the seasonal variation of the stars, so these lines may have been *openly* informative that the year had just ended and Spring was starting.

The Phaecian sailors see Venus rise before arriving in Ithaca (xiii.93). Although not specifically stated we can infer that Venus has risen well ahead of Dawn, since the Phaecians arrive and alight in Phorcys's Bay, drop soundly-sleeping Odysseus and his treasure on the beach, Odysseus wakes up, does not recognize his fog-enveloped country, has a lengthy discussion with Athena during which Athena clears the fog, hides his treasure, and then Athena goes to Sparta to rouse Telemachus, at which time it is daybreak. During this season, Venus rises up to 2 h before sunrise. We shall require that on $T_i - 5$, Venus rise 90 min ahead of the Sun; this happens $\approx 1/3$ of the time.

On Day −34 Hermes arrives far west, and turns back. We interpret this to be an allegory of an apparent turning point of planetary motion. The Antikythera mechanism (35–37) has an inscription for this event (38), called a "sterigmos," or station. There are historical problems with this identification, because the first surviving mention in writing of a connection between the god Hermes and the planet Mercury is in Plato, two to three centuries later. We shall cover this matter in more detail below; for now, let us conjecture this and see where it leads. On $T_i - 34$, Mercury must be on the western side of its trajectory, visible, and close to a turning point. In heliocentric astronomy the significant variable to have a turning point is the elongation from the Sun. In an era of naked eye astronomy and a geocentric cosmogony, the natural variable might have been the rise-time azimuth, i.e., observing the cardinal point on the horizon at which the planet rises, noting when it becomes westernmost; or observing the onset of retrograde motion. These three events are close together in time, although they do not coincide because the Sun rises at different positions every day, carrying Mercury's orbit with it. Thus, our test will require that on $T_i - 34$ Mercury be within a few days of achieving its westernmost rise-time azimuth; this should cover also other turning points.

The final reference is to Poseidon, who was obviously not associated with the planet Neptune (discovered 1846); unlike the Roman Neptune, Homeric Poseidon was associated with the motions of the Earth itself; he is explicitly called the Lord Earthshaker in the passage, and either Earthshaker or Earthholder elsewhere on

---

[¶] Dante describes, at the end of *Inferno*, gravity changing direction, and then flatly states "let the ignorant judge me: those who cannot understand which point we had just crossed" (*Inferno* xxxiv.92). Therefore, Dante, in 1308, believed that all educated readers should be able to figure out that he and Virgil had just crossed the center of the Earth, where gravity changes direction.

the Odyssey and the Iliad (see ref. 39, p. 103). MacDonald (34) conjectured the Earthshaker's return from the southern hemisphere might refer to the Equinox; however, because this identification is far more conjectural than Hermes's travel, we shall not apply this requirement, but merely list it in the table for additional confirmation. Were this identification correct, then $T_i - 11$ should be on or shortly after the Equinox (approximately 1 April); this event, being seasonal, is not independent of the constellations reference, which requires the sinking to be no later than 5 April. There is at most a new moon T_i per year satisfying both these criteria (i.e., 1 April $\leq T_i - 11 \leq$ 5 April).

Intersecting the Constraints

Table S2 lists all years in the range 1250–1115 B.C.E. and whether each criterion is satisfied; Table 2 is abridged to show only years in which the Mercury criterion is close to satisfied. The first column lists T_i, the date of the New Moon on Day 0; the second column lists the rise time of Venus and the Sun on $T_i - 5$ or blank if Venus appears evenings; the third column lists the date of the closest maximum western rise azimuth to $T_i - 34$. The fourth column shows the date $T_i - 11$. The entries are color-coded according to whether they satisfy the criteria above or not; orange means the criterion is fully satisfied, and shades of yellow mean the criteria are narrowly missed; white means the criterion is not close to being satisfied. We colored each year according to the minimum color of the Venus and Mercury constraints, not counting the Equinox. There is a single date T_i in the 135-year span 1250–1115 B.C.E. satisfying all criteria as stated: 16 April 1178 B.C.E. Two days in which the criteria are narrowly missed are discussed in *SI Discussion*; neither satisfies the Equinox reference.

In fact, 16 April 1178 B.C.E. satisfies all five criteria extremely well, both under parallel and under consecutive chronologies, and exactly so under the latter. $T_i - 34$, the day Hermes arrives in Ogygia, would have been 13 March. On 12 and 13 March 1178 B.C. Mercury rose with its westernmost azimuth, but it was not visible on 12 March, because in fact 13 March was its heliacal rising or date of first visibility (using standard parameters for atmospheric extinction and planetary visibility). On $T_i - 29$, 18 March, Odysseus sets sail from Ogygia. At nautical twilight (Fig. 2) the Pleiades were visible astern while Boötes was visible ahead left; it would indeed "set late," in fact be visible through the night. That night is New Moon, and thus the time elapsed between "spreading his sails" on $T_i - 29$ and "stringing his bow" on T_i is exactly one moon; note both images are allegories of the first crescent. The vernal equinox was on 1 April at 3:24 p.m.; the Earthshaker sinks Odysseus four days later, on 5 April. The night before was the heliacal setting of the Pleiades, the last night they were visible before "hiding" for 40 days, and hence Odysseus could not have followed Calypso's directives a single further day. Amusingly, we should note Hesiod states of the heliacal setting of the Pleiades [*Work and Days* (33), pp. 618–621]: "But if desire for uncomfortable sea-faring seize you when the Pleiades plunge into the misty sea to escape Orion's rude strength, then truly gales of all kinds rage" (see *SI Discussion*). Finally, on 11 April, the Phaetians arrive in Ithaca, and Venus rose 1 h 43 min before dawn, with an apparent magnitude of −4.2.

Satisfying all five references this strictly is an extremely infrequent event: Requiring that the sinking of Odysseus's raft be after the equinox (1 April) yet on or before the heliacal setting of the Pleiades (4 April) yields only one T_i every 6 years; one-third of these have a high Venus, and Mercury's sterigmos happens once every 116 days, so the references can be matched exactly only one day every 2,000 years.

In further support of this statistical coincidence, we point out the following: We have not chosen the references to pursue: the ones we have examined are all we have found. As significant as the presences are the absences: Ares does not appear anywhere in the "foreground" story, and Mars was not visible during March/April 1178 B.C.—except at the eclipse. The eclipse happened at noon, as pointed out by Schoch the same time that it appears to occur in the story, and it happens in early spring, which also appears to match the story.

Table 2. Exhaustive search of possible dates (abridged)

Moon/const		Venus			Hermes		Equinox, sinks
Year B.C.	T_i	Rises $T_i - 5$	Sunrise	Difference	MWRA	Δ	$T_i - 11$
1250	2-Apr	4:45:55	6:49:20	2:03:25	7-Mar	-8	22-Mar
1249	22-Mar				21-Feb	-5	11-Mar
1237	8-Apr	5:12:26	6:38:04	1:25:38	9-Mar	-4	28-Mar
1236	28-Mar				23-Feb	-1	17-Mar
1224	14-Apr	5:55:49	6:28:27	0:32:38	11-Mar	0	3-Apr
1223	3-Apr	6:22:27	6:43:05	0:20:38	25-Feb	3	23-Mar
1222	24-Mar				14-Feb	4	13-Mar
1210	10-Apr	4:38:20	6:31:52	1:53:32	27-Feb	8	30-Mar
1209	29-Mar				15-Feb	8	18-Mar
1204	3-Apr				7-Mar	-7	23-Mar
1203	24-Mar				21-Feb	-3	13-Mar
1191	9-Apr	5:27:36	6:34:05	1:06:29	9-Mar	-3	29-Mar
1190	29-Mar				20-Feb	3	18-Mar
1189	18-Mar	5:28:46	7:09:07	1:40:21	5-Feb	7	7-Mar
1178	16-Apr	4:39:45	6:22:41	1:42:56	13-Mar	0	5-Apr
1177	4-Apr				26-Feb	3	24-Mar
1176	25-Mar	6:20	6:58:16	0:38:06	13-Feb	6	14-Mar
1170	19-Mar	4:51:24	7:08:31	2:17:07	20-Feb	-7	8-Mar
1162	20-Mar	4:53:14	7:09:04	2:15:50	6-Feb	8	9-Mar
1158	5-Apr				7-Mar	-5	25-Mar
1157	24-Mar	5:36:23	7:01:35	1:25:12	19-Feb	0	13-Mar
1145	10-Apr				10-Mar	-3	30-Mar
1144	31-Mar	6:22:50	6:50:30	0:27:40	23-Feb	2	20-Mar
1143	20-Mar	6:10:02	7:08:27	0:58:25	12-Feb	2	9-Mar
1131	6-Apr				26-Feb	5	26-Mar
1130	26-Mar	4:56:03	6:59:13	2:03:10	14-Feb	6	15-Mar
1124	20-Mar				20-Feb	-6	9-Mar
1118	12-Apr				28-Feb	9	1-Apr

The full table is available as Table S2. See the text for a description of the columns. Colors indicate suitability: the darker the color, the more suitable the date. Because the fifth reference, the equinox, is conjectural, the colors on the first column only represent the intersection of the other four references.

Historical Plausibility

The analysis above only shows that if one is willing to accept certain passages as astronomical references, then the astronomical phe-

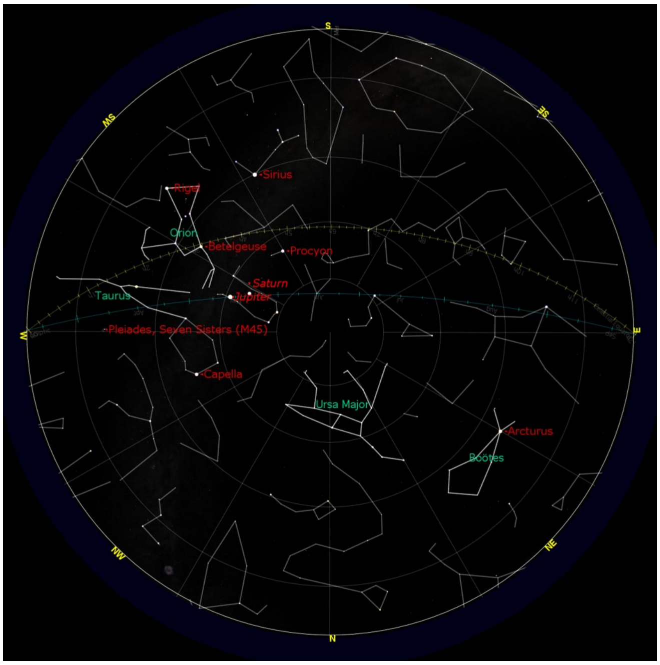

Fig. 2. The sky on 18 March 1178 B.C. at nautical twilight (7:38 p.m.) (Ithaka's latitude), showing the Pleiades retaining the direction of sunset, Boötes ahead, and Ursa Major straight north.

nomena as interpreted "cohere": Two entirely different sets of verses pinpoint the same specific date independently, with a very low probability of this happening by chance. There are two hurdles standing between this low probability and the implication that the lines actually refer to specific astronomical phenomena that happened on a specific date: the historical implausibility of the assumptions, and the historical implausibility of the conclusions.

The three "overt" astronomical references are hardly implausible, because they are quite explicit and have been discussed before. The one implausibility in our assumptions is the identification of Hermes with planet Mercury. The first surviving mention relating Hermes to Mercury is in Plato's Timaeus (5.16), "the star which is called sacred to Hermes." Plato's passage is so matter-of-fact that it appears to imply the term "star of Hermes" was in wide use since, at least, before Plato's birth on 428 B.C. (see ref. 40, Vol. 4, pp. 592–593). The identification of planets with Gods follows from the Hellenization of earlier Mesopotamian associations, a process which must have occurred over a period; were our conjecture to be correct, it would require revising the timetable for such adoption by approximately two centuries, during which no traces were left in the extant texts, although the Homeric Hymn to Hermes describes a story whereby Hermes stole the cattle of Apollo by walking backwards along his own footsteps, which might debatably be considered an allusion to the retrograde motion of Mercury. We evidently cannot support this conjecture further from this angle, because there simply is no material available to decide—one way or the other. We shall attempt, instead, to offer some plausibility from the internal poetic use in the Odyssey itself. Richard Allen noted (ref. 41, p. 305) that the Poet described Orion the hero as having physical attributes (might, size, beauty) which are concordant with those of Orion the constellation. How about Hermes? When we read the lines v.48 onwards we find that the Poet describes Hermes as traveling fast, flying so low and close to the surface of the Ocean that he skims the waves, and he only climbs out of the dark waters as he arrives in Ogygia. The attribute of speed is not too useful in this context, because this attribute was traditional of Hermes and could well have influenced a *later* identification of the fastest god with the fastest planet. But there is a second, nontraditional attribute here: Planet Mercury is never seen far from the horizon, because it is never far from the Sun. Notice also that Hermes climbs out of the dark waters as he reaches Ogygia, and by our analysis this would have happened on 13 March, the first morning visibility of Mercury.

The main implausibility in the conclusions is that they imply that the author of the lines in question was, first, interested in advanced astronomy, at a time when there are no traces left that the Greek had an interest in it beyond calendrical purposes; and in possession of detailed astronomical data of events happening perhaps five centuries before him.

That the Poet was interested in astronomical matters was pointed out by Gilbert Murray, who noticed that the conjunction of a solar and lunar cycle and the 19 years it took Odysseus to return home both agreed with a Metonic cycle, and that the stories of Odysseus's return (the shroud being knitted and unknitted and the stringing of the bow) are clear lunisolar allegories. In further support of Murray's hypothesis we point out, first that the Metonic cycle is an eclipse repeat cycle; and second, that the Poet puts Odysseus leaving Calypso precisely one moon before revealing himself in Ithaka, and the image used to describe that moment is of him "spreading his sails"—another first crescent allegory (see *SI Discussion*).

As to the data, it is quite improbable, although not entirely impossible, that it had been observed and noted, preserved through oral tradition for centuries, and then incorporated into the story by the Poet. The main argument against this possibility is that the data we've examined requires observations of a high level of sophistication for the time and place and its precise preservation in oral tradition. We examine now other possibilities.

The 1178 B.C. eclipse was specifically observed over the Ionian islands and its track does not appear to have passed close to any of the great civilization centers at the time where observations would have been made, making the existence of a record of the eclipse rather dubious. As stated this sounds implausible indeed. But it might be a mistake to argue that the *only* avenue for obtaining such knowledge would have been historical astronomical observations taken in Ithaka, of a degree of precision comparable or exceeding Chaldean observations, and mysteriously preserved for centuries. In particular, one does not need to assume that the information about the eclipse and the information about planetary positions come from the same sources, and as only the eclipse is specific to the Greek islands it evidently is the one main hurdle.

Let us take a step back and examine the classical discussion of the alleged prediction of the 28 May 585 B.C. eclipse by Thales. Most historians consider this chapter closed, based on the strength and fervor of Neugebauer's argument (ref. 42, p 604): Neither the Greeks nor the Mesopotamians had the mathematical tools required to compute the track of an eclipse at the time, a complex endeavor requiring high numerical accuracy and a sophisticated lunar theory. While the Metonic and Saros eclipse cycles are thought to have been known in Mesopotamia at the time, Neugebauer vigorously asserted that they couldn't be used to predict visibility at a given locale, because "there exists no historically manageable cycle of solar eclipses visible at a given locality." He closes his argument stating, "Hence there is no justification for considering the story of Thales eclipse as a piece of evidence for Babylonian influence on earliest Greek astronomy." While his note of caution is correct and should be heeded, we believe his argument to be subtly flawed, because two potential "loopholes" do exist. First, we're discussing two sites rather than one. Second, intercalated exactly at the half cycles are total lunar eclipses observable from half the planet. As applied in particular to Thales's alleged eclipse prediction: one Saros cycle before the eclipse of 28 May 585 B.C., on 18 May 603 B.C., the line of totality passed 220 km southeast of Ur, darkening the entire northern coast of the Persian gulf down to modern-day Al Jubayl; half a Saros cycle before 585

B.C., on 23 May 594 B.C., there was a total lunar eclipse visible from both Greece and Mesopotamia. Therefore, we submit that predicting the precise date of Thales's eclipse was quite possible at the time using cycles, although evidently predicting *visibility* would have been quite astonishing, and the traditional story does not state the latter to have happened.

The relation of this detour to our Homeric case is the following. One exeligmos (three Saros) *after* the eclipse of 16 April 1178 B.C., on 18 May 1124 B.C., the track of totality passed almost exactly over Babylon; in fact, the point of greatest eclipse is estimated to have been 32.9°N,45.3°E, 90 km ENE of Babylon. The point of greatest eclipse of the 1178 B.C. eclipse is estimated to be 32.7N 12.7E, 33° directly west of Babylon, 50 km WSW of Tripoli. Any additional knowledge that the eclipse track of the Babylonian eclipse was tilted NE to SW might have permitted estimating that the 1178 B.C. eclipse passed over Greece (see Fig. S2). We again emphasize that we do not espouse that this is how the Poet came into this information; we only argue that alternative means of obtaining this information might have been available at the time.

Conclusions

We hasten to point out that our case is still far from proved. Our only modest success is in showing that if our identification of certain poetic passages in the Odyssey with certain astronomical phenomena is correct, then these references "cohere," in the sense that the astronomical phenomena pinpoint the date of 16 April 1178 B.C.E. independently of the disputed eclipse reference. The odds that purely fictional references to these phenomena (so hard to satisfy simultaneously) would coincide by accident with the only eclipse of the century are minute. However, if the identification of the poetic passages with the phenomena were incorrect, then our whole calculation would be a nonsequitur.

We do believe our identification of passages with phenomena to be plausible, and the coherence of the phenomena to suggest (post hoc) that these astronomical references (including the disputed eclipse reference) may be the work of the same hand, and may indeed refer to the historical eclipse of 16 April 1178 B.C. shown in Fig. 1. These references are structural and define the timeline of the epic, forming a layer akin to finding a perspective grid drawn in pencil behind a painting. The whole poem might then be structured to follow what the stars dictate, because the references mandate how long Odysseus has to build his raft, when he should be sunk, or how long he must remain hidden in Ithaka before revealing himself. We conjecture the references are the work of the Poet who crystallized the many, still fluid, traditional narratives into the structure we know today, endowing it with a timeline; for lack of a better name, and purely conjecturally, we call this poet "Homer."

We again emphasize that even if our analysis were correct, we still could not say whether anything other than an eclipse happened that 16 April, because it is equally compatible with a historical Odysseus, or with an allegorical Odysseus whose wanderings were structured, deliberately, according to an astronomical timeline. Either case, our conjectural Homer would have had to be aware that there was an eclipse on a certain date and what the planets did on nearby dates. This is problematic enough, because the dates were centuries before his time; how this knowledge was acquired—we dare not conjecture, for all possibilities sound equally outlandish. Much research is needed before we can move beyond such speculations; we can only modestly hope to convince other scholars that the case against Schoch's eclipse may have been too hastily closed, and just inspire them to ponder if the remarkable coincidence described in this paper may in fact not be coincidental at all.

ACKNOWLEDGMENTS. We are deeply indebted to Mitchell Feigenbaum and Michael Rout for lengthy astronomical instruction, and to Paul Nurse, Jan Skotheim, Robert Bittlestone, James Diggle, Lauren Gravitz, K. Kelly, and Noel Swerdlow for helpful critical comments.

1. Schoch C (1926) The eclipse of Odysseus. *The Observatory* 49:19–21.
2. Espenak F, Meeus J (2006) Five millennium canon of solar eclipses: −1999 to +3000. *NASA Tech Publ TP-2006-214141*.
3. Guillermier P, Koutchmy S (1999) *Total Eclipses: Science, Observations, Myths and Legends* (Springer/Praxis, London).
4. Littmann M, Willcox K, Espenak F (1999) *Totality: Eclipses of the Sun* (Oxford Univ Press, New York).
5. Brunier S, Luminet J-P (2000) *Glorious Eclipses: Their Past, Present, and Future* (Cambridge Univ Press, Cambridge, UK).
6. Plutarch Lives, §21: Pelopidas.
7. Plutarch De facie in orbe lunae, §19.
8. (ps)Plutarch De Vita et Poesi Homeri, §108.
9. Heraclitus Quaestiones Homericae, §75.
10. Page DL (1955) *The Homeric Odyssey* (Clarendon, Oxford).
11. Fotheringham JK (1921) *Historical Eclipses: Being the Halley Lecture Delivered 17 May 21* (Clarendon, Oxford).
12. Schoch C (1926) *Die Sterne* 6:88.
13. Schoch C (1926) *Die sechs griechischen Dichter-Finsternisse* (Steglitz, Selbstverlag, Berlin).
14. Neugebauer PV (1929) *Astronomische Chronologie (zwei Bände)* (de Gruyter, Berlin).
15. Odenwald SF (2003) *Back to Astronomy Café (Table 12)* (Westview, Boulder, CO).
16. Espenak F, *Solar Eclipses of Historical Interest* (National Aeronautics and Space Administration, Greenbelt, MD). Available at http://eclipse.gsfc.nasa.gov/SEhistory/SEhistory.html.
17. Campbell J (1964) *The Masks of God: Occidental Mythology* (Viking, New York).
18. Murray G (1924) *The Rise of the Greek Epic; Being a Course of Lectures Delivered at Harvard University* (Clarendon, Oxford).
19. De Santillana G, von Dechend H (1969) *Hamlet's Mill; An Essay on Myth and the Frame of Time* (Gambit, Boston).
20. Meeus J (1998) *Astronomical Algorithms* (Willmann-Bell, Richmond, VA).
21. Stephenson FR (1979) Modern look at ancient eclipses. *New Sci* 81:560–562.
22. Stephenson FR (1982) Historical eclipses. *Sci Am* 247:170.
23. Stephenson FR, Lieske JH (1988) Changes in the earth's rate of rotation between AD 1672 and 1806 as deduced from solar eclipse timings. *Astron Astrophys* 200:218–224.
24. Stephenson FR, Said SS (1989) Non-tidal changes in the earth's rate of rotation as deduced from medieval eclipse observations. *Astron Astrophys* 215:181–189.
25. Stephenson FR (1997) *Historical Eclipses and Earth's Rotation* (Cambridge Univ Press, Cambridge, UK).
26. Morrison LV, Stephenson FR (2001) Historical eclipses and the variability of the earth's rotation. *J Geodynamics* 32:247–265.
27. Morrison LV, Stephenson FR (2002) Ancient eclipses and the earth's rotation. *Highlights Astron* 12:338–341.
28. Stephenson FR (2003) Historical eclipses and earth's rotation. *Astron Geophys* 44:22–27.
29. Morrison LV, Stephenson FR (2004) Historical values of the earth's clock error at and the calculation of eclipses. *J Hist Astron* 35:327–336.
30. Morrison LV, Stephenson FR (2005) Historical values of the earth's clock error Delta T and the calculation of eclipses (vol 35, pg 327, 2004). *J Hist Astron* 36:339.
31. Starry Night Software (2006) Starry Night Pro, version 6.0.4 (Imaginova, Watsonville, CA).
32. Lange R, Swerdlow NM (2006) Planetary, Lunar, and Stellar Visibility (Alcyone Software), Ver 3.0. Available at www.alcyone.de.
33. Hesiod, Lombardo S, Lamberton R, Hesiod (1993) *Works and Days; and Theogony* (Hackett, Indianapolis).
34. MacDonald TL (1967) The season of the Odyssey. *J Br Astron Assoc* 77:324–328.
35. Turner GL (1993) The ancient-Greek computer from Rhodes known as the antikythera mechanism—Kena, Vj. *Interdiscip Sci Rev* 18:401.
36. Edmunds M, Morgan P (2000) The antikythera mechanism: Still a mystery of Greek astronomy? *Astron Geophys* 41:10–17.
37. Wright MT (2001) The antikythera mechanism. *Astron Geophys* 42:9.
38. Freeth T, *et al.* (2006) Decoding the ancient Greek astronomical calculator known as the antikythera mechanism. *Nature* 444:587–591.
39. Bittlestone R, Diggle J, Underhill J (2005) *Odysseus Unbound: The Search for Homer's Ithaca* (Cambridge Univ Press, Cambridge, UK).
40. Jacoby, F (1923) *Die Fragmente der griechischen Historiker: (F GR HIST)* (Weidmann, Berlin).
41. Allen RH (1899) *Star Names and Their Meanings* (Stechert, New York).
42. Neugebauer O (1975) *A History of Ancient Mathematical Astronomy* (Springer, Berlin).