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LEVI BEN GERSON AND THE BRIGHTNESS OF MARS*

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In the period from Ptolemy to Kepler, dated observations of Mars were generally made to determine its position in longitude, and many of the reports refer to Mars when it was in opposition to the Sun.[1] One finds very little discussion of the variation in the brightness of Mars, and there was the added difficulty, from a modern point of view, that size and brightness were not properly distinguished. Indeed, a brighter star or planet was thought to have a greater apparent diameter than a dimmer such celestial object. As a result, discussions of the variation in the brightness of Mars were generally presented as discussions of its variation in apparent angular size. If we restrict our attention to dated or datable observations of the size or brightness of Mars, there are only two astronomers who made such observations: Levi ben Gerson (1288–1344), and Philip Melanchthon (1497–1560), and Levi ben Gerson was alone in stating unambiguously that the brightness varied at different oppositions.

There are two senses in which one might consider the variation in the brightness of Mars: the first concerns the variation in brightness in the synodic cycle of Mars, i.e., Mars is much brighter at opposition to the Sun than when it is near conjunction with it;[2] the second concerns the variation in the brightness of Mars at oppositions to the Sun. It is the second sense that is particularly interesting. There is nothing in Ptolemy's *Almagest* about the size of the planets, but in his *Planetary hypotheses* he gives a set of values and, among them, the apparent diameter of Mars is given as 1/20 that of the Sun.[3] No specific dated observation is cited, and Ptolemy assigns this value to Mars at its mean distance in a geocentric framework. I have found only a few other references to the size or brightness of Mars in Antiquity, and none of them is dated or datable.[4] In the Middle Ages, Ptolemy's values for the sizes of the planets were often repeated and the value for Mars was occasionally criticized. But these criticisms were not based on dated observational reports; rather, they were based on the computation of the ratio of maximum to minimum distance of Mars from the Earth according to Ptolemy's model, and applying this ratio to Ptolemy's value for the apparent size at mean distance. The resulting variation in the size of Mars seemed too great, and the maximum apparent size of Mars seemed much too large.[5]

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*Dedicated to the memory of LeRoy E. Doggett (1941–1996), Head of the Nautical Almanac Office, US Naval Observatory, whose advice was always dependable and graciously given. Indeed, he was in the process of responding to some of my inquiries when his last illness made it impossible for him to continue his work. He will be greatly missed by both astronomers and historians of astronomy.

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The only datable observations of the brightness of Mars that I found before the sixteenth century were made by Levi ben Gerson, and reported in Chapter 17 of his *Astronomy*. He considered Mars at three oppositions: at the first Mars was in the zodiacal sign, Leo; at the second it was in Capricorn; and at the third it was in Scorpio. Levi does not give the dates of his observations, but Mars in opposition in Leo took place in February 1333, in Capricorn in June/July 1339, and in Scorpio in April/May 1337 — no other dates in Levi's lifetime are possible. Levi's credentials as an observer are supported by well over 50 astronomical observations made between 1321 and 1340, including 13 of Mars, and this list of dated observations by a single astronomer is one of the most extensive in the Middle Ages.[6]

Levi's account is brief, and he seems to have been surprised by his observations, judging by the *ad hoc* explanations he offers:

> When Mars was retrograde in Leo, we found its size perceptibly greater than that of Saturn, and similarly in Capricorn, but there its size appeared greater than it was in Leo. However, when it was retrograde in Scorpio its size did not seem greater than that of Saturn. ... You should know that we ascribed what we first discovered concerning Mars in Leo to thin clouds through which it was seen at that time. We did this because during its retrogradation in Scorpio its size was not found to be augmented, and because we did not see this increment in the proper order in which it should take place were it due to its closeness to us. You cannot argue that after a short time it [Mars] can appear to be smaller in size than what follows from the appropriate ratio, for we observed its size while retrograde in Capricorn where we found it somewhat augmented as compared to the size that we found it in Leo. We also ascribed the absence of an increment in the size of Mars in Scorpio to the thickness of vapours through which it was seen at that time. We then understood that this phenomenon took place because of the comet that continued to appear for more than three months; that vapour came into being under Scorpio and it was drawn from there to somewhat below the north pole: there it burst into flame and it perished in Scorpio.[7]

In previous comments on this chapter, I noted that the comet in question can be dated to 1337, on the basis of observations in China and in Europe,[8] and this is consistent with dating the opposition of Mars in Scorpio to April/May 1337. I take Levi's appeal to comet formation, clouds, and the thickness of vapours to be part of his explanation for anomalous phenomena, rather than as part of the observational reports. According to modern theory, the brightnesses of Mars at its closest approach to the Earth near these three oppositions were: 1333 Feb 8, $M = -1.3$; 1337 May 3, $M = -2.0$; 1339 Jul 1, $M = -2.8$.[9] This variation is not surprising, given that the brightness of Mars at opposition depends on its position relative to its perihelion — when an opposition takes place in February, Mars is near aphelion and hence dimmest, whereas when an opposition takes place in August, it is near perihelion and hence brightest.[10] Levi's report that Mars at opposition in 1337 was not as large (i.e., bright) as Saturn is a puzzle for which I have no explanation.

It may seem that Levi ought to have compared Mars with Jupiter, whose brightness it rivalled in 1339, rather than with Saturn, but on those three occasions, Mars was much closer to Saturn than to Jupiter. On 1333 Feb. 8 the longitude of Mars was about 145°, Jupiter about 305°, and Saturn about 182°; on 1337 May 3, Mars was about 219°, Jupiter about 75°, and Saturn about 227°; on 1339 Jul 1, Mars was about 277°, Jupiter about 139°, and Saturn about 247°.[11] It is also not clear how Levi was able to compare the brightnesses of Mars seen six years apart.

Melanchthon is best known as one of the founders of the Lutheran Church, and his interest in astronomy and astrology had an important impact on his contemporaries.[12] In his *Initia doctrinae physicae* (1549), there is a section on astronomy and astrology in which he reports one dated observation of Jupiter and one of Mars.[13] For Mars, we are told that in July 1529, when retrograde, it was unusually large ("inusitata magnitudine"). It is unclear whether Melanchthon intended to say that Mars was unusually large (i.e., bright) as compared with other oppositions, or as compared with Mars at other times in its synodic cycle. One is tempted to say that he meant the former, because that would be correct and more interesting from a modern point of view, but I do not see how a contemporary reader could have come to that understanding without independent evidence that Mars varied in brightness at oppositions.

Galileo criticized his predecessors, including Tycho Brahe, for overestimating the apparent sizes of the planets, but does not mention the variation in the apparent brightness of Mars at oppositions in any passage I have found.[14] Although Levi's text was available in both Hebrew and Latin manuscripts, I have seen no evidence that anyone appreciated his discovery of this phenomenon. Similarly, I have found no reference to the observation of Mars by Melanchthon among his successors, despite the considerable influence he had on them. In sum, there was little interest in the variation in the apparent brightness of Mars at oppositions.

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1. See, for example, *Almagest* x.7; G. J. Toomer, *Ptolemy's Almagest* (New York and Berlin, 1984), 484.
2. This variation is clearly stated in Rheticus's *Narratio prima*, ed. and transl. by H. Hugonnard-Roche

et al. (Warsaw, 1982), 55 (Latin), 107 (French), 162 n. 86; and in Copernicus's *De revolutionibus* (Nuremberg, 1543), i.10, 10r.

3. B. R. Goldstein, *The Arabic version of Ptolemy's Planetary Hypotheses* (Philadelphia, 1967), 8.

4. The best known passage is in Simplicius's *Commentary on Aristotle's De caelo*: for the text with translation, see Autolycos de Pitane, *La sphère en mouvement, Levers et couchers héliaques, Testimonia*, ed. and transl. by G. Aujac (Paris, 1979), 179; for passages in Proclus, see *Procli diadochi Hypotyposis astronomicarum positionum*, ed. and transl. by C. Manitius (Leipzig, 1909), i.18, 10–11; and Proclus, *Commentaire sur la République*, transl. by A. J. Festugière (3 vols, Paris, 1970), iii, 171.

5. Notable among Ptolemy's early critics who discussed the problems of Mars were al-'Urḍī, Levi ben Gerson, Henry of Hesse, and Regiomontanus. According to al-'Urḍī, the difficulty with Ptolemy's data was that Mars at opposition should appear to be larger than Venus but this has not been observed; according to Levi ben Gerson, the observed ratio of sizes at maximum and minimum distances is 2 to 1 whereas Ptolemy's model implies a ratio of 6 to 1; according to Henry of Hesse, Mars can be smaller than a first magnitude star whereas the size of Mars in the Ptolemaic tradition is equal to that of a first magnitude star; and according to Regiomontanus, the ratio of apparent areas of Mars at maximum and minimum distances with Ptolemy's data should be 52 to 1, but Mars never appears so large. On al-'Urḍī, see B. R. Goldstein and N. Swerdlow, "Planetary distances and sizes in an anonymous Arabic treatise preserved in Bodleian Ms. Marsh 621", *Centaurus*, xv (1970–71), 135–70, espec. pp. 148, 163 (reprinted, with additional notes, in B. R. Goldstein, *Theory and observation in ancient and medieval astronomy* (London, 1985), chap. VI). On Levi ben Gerson, see B. R. Goldstein, *The astronomy of Levi ben Gerson (1288–1344)* (New York and Berlin, 1985), chap. 17, 105–6. On Henry of Hesse, see J. L. Mancha, "Henry of Hesse's criticism of Ptolemaic cosmology" (in preparation). On Regiomontanus, see N. M. Swerdlow, "Regiomontanus on the critical problems in astronomy", in *Nature, experiment and the sciences*, ed. by T. H. Levere and W. R. Shea (Dordrecht and Boston, 1990), 165–95, espec. p. 173. For similar discussions of Venus, see B. R. Goldstein, "The pre-telescopic treatment of the phases and apparent size of Venus", *Journal for the history of astronomy*, xxvii (1996), 1–12.

6. See B. R. Goldstein, "Medieval observations of solar and lunar eclipses", *Archives internationales d'histoire des sciences*, xxix (1979), 101–56, and *idem*, "A new set of fourteenth century planetary observations", *Proceedings of the American Philosophical Society*, cxxxii (1988), 371–99.

7. Goldstein, *The astronomy of Levi ben Gerson* (ref. 5), 106–7. For the Latin version of this discussion of the comet of 1337, see J. L. Mancha, "The Latin translation of Levi ben Gerson's *Astronomy*", in *Studies on Gersonides: A fourteenth-century Jewish philosopher-scientist*, ed. by G. Freudenthal (Leiden, 1992), 21–46, espec. pp. 32 and 44.

8. Goldstein, *The astronomy of Levi ben Gerson* (ref. 5), 188; and B. R. Goldstein, "Theory and observation in medieval astronomy", *Isis*, lx (1972), 39–47, espec. p. 45.

9. These computed values were kindly provided to me by B. Marsden and his assistant, G. Williams, based on the following formula for the magnitude of Mars at opposition: $M = -1.52 + 5 \log (r \cdot d)$, where r is the heliocentric distance of Mars, and d is the geocentric distance of Mars, in astronomical units.

10. S. Newcomb, *Popular astronomy*, 5th edn (New York, 1884), 326–7; and G. C. Flammarion and A. Danjon, *The Flammarion book of astronomy*, transl. by A. Pagel and B. Pagel (New York, 1964), 283–4.

11. B. Tuckerman, *Planetary, lunar, and solar positions, A.D. 2 to A.D. 1649* (Philadelphia, 1964), 684, 686, 687.

12. R. S. Westman, "The Melanchthon circle, Rheticus, and the Wittenberg interpretation of the Copernican theory", *Isis*, lxvi (1975), 165–93; S. Kusukawa, *The transformation of natural philosophy: The case of Philip Melanchthon* (Cambridge, 1995).

13. C. G. Bretschneider (ed.), *Philippi Melanchthonis Opera quae supersunt omnia* (28 vols, Halle, 1834–60), xiii, cols. 268 (Jupiter) and 274 (Mars).

14. *Cf.* A. Van Helden, *Measuring the universe* (Chicago, 1985), 70–76.