A curiosity: Did Ptolemy see Uranus?

N. M. Swerdlow

The short answer to this question is, probably not, or it cannot be answered. The long answer is more interesting, indeed, a curiosity. There were a number of sightings with a telescope of Uranus and Neptune, assumed to be faint stars, before their discovery and identification as planets in 1781 and 1846. The earliest and most remarkable were Galileo's observations, in his measurements of elongations of Jupiter's satellites on 28 December 1612 and 28 January 1613, of a star that turned out to be Neptune. In the second observation he noted that, compared to an unrecorded observation the preceding night in relation to another star, "they (the stars) appeared more distant from each other" (*videbantur remotiores inter se*), so he actually saw Neptune move (about 0;1° retrograde).[1] Neptune is always about magnitude 8, so can be seen only with a telescope, but Uranus varies from about 5.4 to 6, so in principle can be seen with the unaided eye under favorable conditions of a clear, dark sky. I have been able to learn little of unaided sightings of Uranus since its discovery, although if its location is known and conditions are favorable, it should be possible to see along with other stars of magnitude 5.5 to 6. John Tebbutt of the Windsor Observatory of New South Wales reported that several weeks after its opposition of 15 February 1878, Uranus can be "distinctly seen without a telescope," and with a telescope its brightness is comparable to ν Leonis, about 0;45° below the planet, of magnitude 5½. Then, on 18 March 1880, twenty-one days after opposition, "by means of the naked eye and also a small telescope," he compared its brightness with BAC 3621 of magnitude 5½ and BAC 3622 of magnitude 6, finding Uranus about equal to 3621 and superior to 3622.[2]

Following William Herschel's discovery of Uranus, there were examinations of earlier star catalogues to find possible observations with coordinates that could be used to determine and refine the elements of its orbit. The first to do this, even before it had been definitely confirmed as a planet, was Johann Bode, and one of the stars he investigated was from pre-telescopic observation. This was the 27th star in Capricorn in Tycho's catalogue, for epoch 1 January 1601, described as "preceding (east of) this (26, the southern star in the upper part of the tail) to the north," of longitude Aquarius 20;16°, latitude –0;10°, magnitude 6, which Hevelius had found did not exist. Using an identification of a star observed by Tobias Mayer in 1756 as the planet, which turned out to be correct, he provisionally assumed the same for the star in Tycho's catalogue and, using an observation from 1589, calculated back 166 years 10 months, finding a period for the planet of 80 years 8 months. But when he received Laplace's elements in 1784, with a period of over 83 years, Bode realized there was a difference of 24° of longitude and withdrew his identification.[3] Recently, K. P. Hertzog has proposed that the 17th star in Virgo in Ptolemy's

1 This discovery was made by Stillman Drake and Charles Kowal, and published in Galileo's Sighting of Neptune, *Scientific American* 243 no. 6 (1980), 74-81. It is reprinted in Stillman Drake, *Essays on Galileo and the History and Philosophy of Science* 1, Toronto, 1999, 430-41.

2 *Journal and Proceedings of the Royal Society of New South Wales* 12 (1878), 220-21; *idem* 14 (1880), 23, in which he also notes, "Some idea may be formed of its conspicuous character when it is stated that I determined pretty accurately its distance from Regulus and γ Leonis by means of an ordinary sextant."

3 A. F. O'D. Alexander, *The Planet Uranus, A History of Observation, Theory and Discovery*, New York, 1965, 81-82, with a

Instruments – Observations – Theories: Studies in the History of Astronomy in Honor of James Evans, ed. Alexander Jones and Christián Carman, 2020, DOI: 10.5281/zenodo.3928498, pp. 143–146. Chapter DOI: 10.5281/zenodo.3975731.

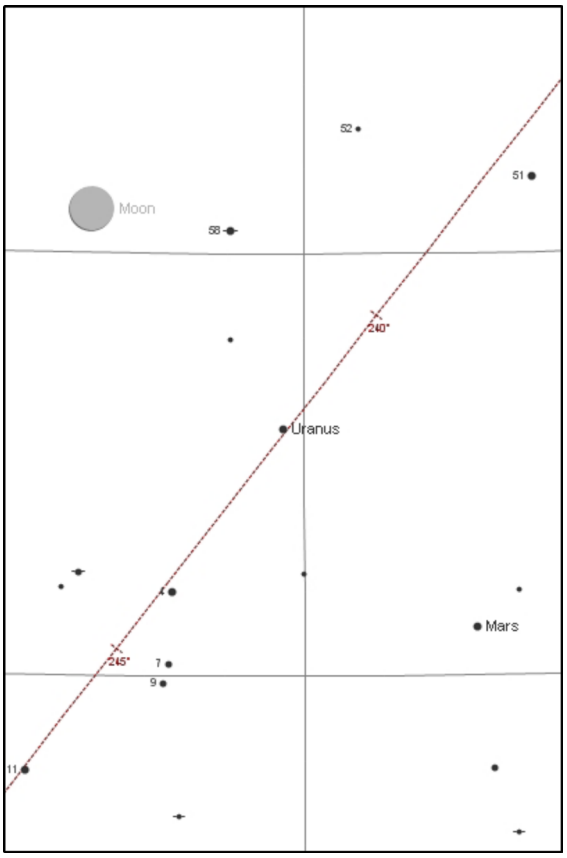

Figure 1. The Moon, Uranus, and Mars, 139 May 30, 8:35 PM in Alexandria.

star catalogue, longitude Virgo 27¼°, latitude +0⅛°, magnitude 6, doubtfully identified as 76(h) Virgo, then at longitude 179;21°, latitude –0;18°, differing by +2;6° and –0;28°, is actually Uranus, observed, not by Ptolemy, but by Hipparchus, possibly on or near 25 March –127, when Uranus was at longitude 175;12°, latitude +0;45°, an elongation from the sun of 173°, close to opposition and thus brightest.[4]

list of twenty-two pre-discovery telescopic observations, 90. E. G. Forbes, The Pre-Discovery Observations of Uranus, *Uranus and the Outer Planets*, ed. G. Hunt, Cambridge, 1982, 67-80. The story of the "missing" 27 Cap in Tycho's catalogue, identified as μ Cap by Beyer and ever since, is complicated and related to problems in 26 Cap. In addition to the catalogue, *Tychonis Brahe Dani Opera Omnia*, ed. J. L. E. Dreyer, Copenhagen, 1913-29, 2.264.24, there are, in a lengthy series of observations of zodiacal stars in 1589, 11.363, on 20 November distances of 27 and 28 from 2 Pisces (southern of the two stars in the back of the head), and in a catalogue of observations in 1589 of zodiacal stars, in equatorial coordinates and converted to ecliptic coordinates, 11.405, coordinates of 27, of which Dreyer notes, "This location is false since there is no star in this place." There is an analysis of the problems of 26 and 27 by D. Rawlins, Tycho's 1004-Star Catalog, *Dio* 3, 1993, 32-33.

4 K. P. Hertzog, Ancient Uranus?, *Quarterly Journal of the Royal Astronomical Society* 29 (1988), 277-79. Hertzog prefers Baily's consecutive numbering for the entire catalogue, used by Peters and Knobel, B513, for 17 Virgo, and for the longitude Virgo 27°. It is possible that the text is erroneous, by –1° (ζ for η) in longitude, north for south (βο for νο) in latitude. At the end of *Almagest* 7.4 Ptolemy refers to (some number of) descriptions of constellations and positions of stars, meaning coordinates close enough to his own to identify the stars, by his predecessors. The assumption that he adapted exclusively Hipparchus's star catalogue requires a difference from his coordinates of –2;40° in longitude and the same latitude, or something close, and here for Uranus the differences from the text are –2;3° in longitude, or –1;48° for Virgo 27°, and +0;35° in latitude, although the text could be erroneous. Still, errors of over

But there is an observation of another kind, an observation actually dated and reported, for which the question can be asked of whether Uranus was seen. In *Almagest* 10.8 Ptolemy reports an observation of Mars, three days after opposition to the mean sun, to determine the radius of its epicycle. The observation, of Mars and the moon, was in the second year of Antoninus, Epiphi 15/16 at an apparent time of three equal hours before midnight in Alexandria (139 May 30/31, 9 PM). Using the astrolabe (armillary with graduated rings) for direct measurement of longitude, set on Spica with the 20th degree of Libra culminating, he found Mars at Sagittarius 1⅗° and the same distance, 1⅗°, to the east of the moon, meaning difference in longitude. The computed longitude of the moon, corrected for parallax, was Sagittarius 0°, so the two measurements confirmed the same longitude of Mars, Sagittarius 1;36°. Toomer has found that in computing the position of the moon, Ptolemy applied an equation of time of –0;23^h, which correctly from his tables should be about –0;25½^h.[5] The configuration of the observation for a mean time of 8:35 PM in Alexandria is shown in Figure 1, in horizon coordinates, 7° of azimuth, 10° of altitude, with nearby stars of Sagittarius and Ophiuchus of fourth to sixth magnitude. The bodies are located in the south-east 20½° to 25½° above the horizon, and the diagonal line is the ecliptic.

It can be seen that Uranus, almost exactly in the ecliptic, is about midway between Mars and the moon, and that is what is interesting about the observation. The computed coordinates of the three bodies and the sun, azimuth measured from south to west and the horizon coordinates corrected for refraction, along with Ptolemy's longitudes, the moon corrected for parallax in both, and the computed magnitudes, are as follows:[6]

	Azimuth	*Altitude*	*Longitude*	*Latitude*	*Ptolemy's Longitude*	*Magnitude*
Moon	312;15°	+25;31°	240;22°	+3;55°	240; 0°	–12.5
Uranus	314;44°	+22;45°	241;45°	+0; 2°	—	5.5
Mars	317;10°	+20;34°	242;12°	–3;12°	241;36°	–2.5
Sun	131;34°	–18;53°	66;41°	—	65;27°	—

The angular separation of Mars and the moon is about 7;21°, of Mars and Uranus 3;16°, and of Uranus and the moon 4;8°. Since the altitude of the sun is about –19°, astronomical twilight has just occurred, which is favorable for seeing faint stars. Uranus, 175° from the sun, near opposition, is at its brightest, but the moon, 174° from the sun, is nearly full, which is unfavorable.

Now, could Ptolemy have seen Uranus as a faint star between Mars and the moon in making this observation? Again, as in the short answer, probably not, in fact, almost certainly not as seeing a star of magnitude 5.5 about 4° from the full moon seems very unlikely if not impossible. But the matter is not hopeless. The observation followed by three days the third of Ptolemy's oppositions of Mars, Epiphi 12/13, two equal hours before midnight (139 May 27/28, 10 PM, it appears mean time), used to find its eccentricity and direction of its apsidal line. In order to find

---

½° in the observations are entirely possible, so any decision rests upon first determining whether the coordinates of this star were adapted from Hipparchus. I do not know how to do this.

5 G. J. Toomer, *Ptolemy's Almagest*, New York, 1984, 499, n. 57. There is much of interest about this observation, but our concern here is the time, for which we use a mean time of 8:35 PM in Alexandria.

6 The coordinates and magnitudes, here and throughout this paper, are computed and the figures are drawn using Alcyone Ephemeris 3 with Δ*T*, the secular acceleration, from JPL Horizons Ephemeris; with other values of Δ*T* the longitude of the moon is about 0;6° less. Ptolemy gives the mean longitude of the sun, Gemini 5;27°, virtually at apogee; the true longitude differs by less than +0;1°.

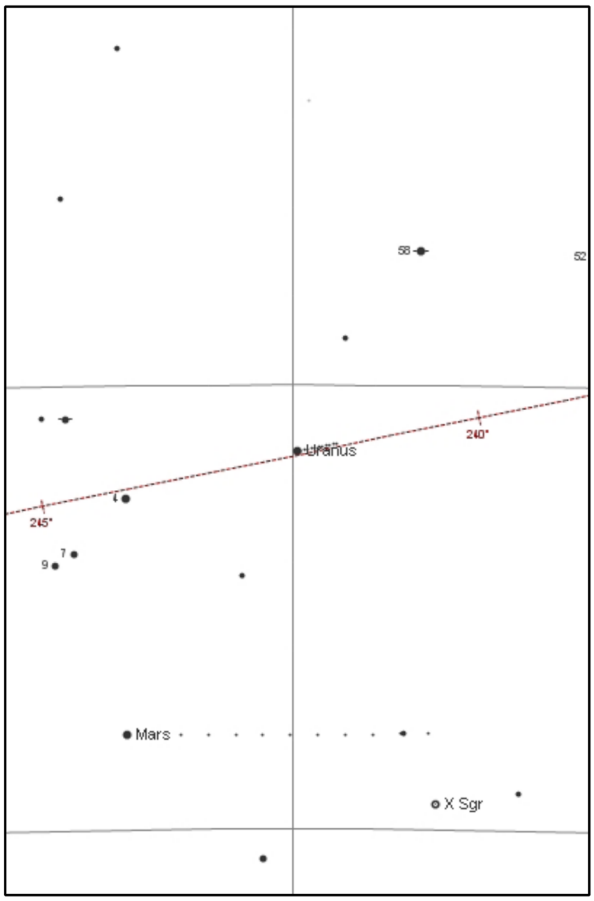

Figure 2. Mars and Uranus, 139 May 22 to June 2, 10 PM in Alexandria.

the time of opposition to the mean sun by interpolation, Ptolemy measured the longitude of Mars using the astrolabe on successive nights before and after the anticipated time, including the observation on May 30 three days after opposition. On earlier nights, Mars and Uranus were less than 4° apart, with the moon 40° to the west at opposition and 75° to the west three nights before opposition, setting at about 1:30 AM, so less likely to overwhelm the light of a faint star at those distances. Figure 2, in equatorial coordinates, 7° of right ascension, 10° of declination, shows the paths of Mars and Uranus, both retrograde from left to right, from May 22 to June 2 for 10 PM in Alexandria, during which time the distance of Uranus from Mars is between 3;43° and 3;16°.

So if in measuring the longitude of Mars from night to night with the astrolabe, or simply in looking in the direction of Mars if the ecliptic ring blocked seeing close to the ecliptic, Ptolemy noticed a faint star about in the ecliptic above Mars, he would have seen Uranus. (I realize that this will not be welcomed with delight by Ptolemy's critics.) But perhaps this is too optimistic, for even if the star could be *seen*, it may not have been *noticed*, and concerning this I have no opinion. Still, the configuration, very nearly in a line, of the moon, Uranus, and Mars at the very time of Ptolemy's measurement of the distance in longitude of Mars from the moon, and Mars and Uranus remaining close together during the several nights Ptolemy measured the position of Mars to find its opposition, are remarkable, the earliest, and only, (possible) sighting of Uranus for which there is evidence that someone was actually looking, and looking in the right place, and for that reason is worthy of notice. And it certainly is a curiosity.