

years before Ptolemy, the physically more insightful model of Aristarchus had been proposed.

References

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I suggest an additional myth to Mano Singham's delightful account. That is the myth that the heliocentric theory was conceived by Copernicus with no precedent. In the third century BC, Greek astronomer Aristarchus of Samos postulated the theory. He had correctly calculated the size of the Moon and its distance from Earth. He also calculated the Sun's size and its distance from Earth, but his results for the Sun were far wrong because he lacked instruments to correctly obtain an angular measurement. Nevertheless, those calculations apparently led him to the idea that Earth revolves around the Sun. Aristarchus also concluded that the fixed stars were almost infinitely far away, and he thus explained the lack of parallax in our solar circumnavigation. So he essentially had the big picture.

Copernicus mentioned Aristarchus in earlier versions of his text, but he later deleted such mention.

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The article on Copernican myths was interesting in baring the tendency of physicists to rewrite their histories, but it is clear there are other myths that even Mano Singham perpetuates. In the Ptolemaic system, the planets did not move uniformly in circles about Earth. The motion of a planet was in two circles: an epicycle on which the planet moves, and a main cycle on which the center of the epicycle moves. Although both were circles, neither centered on Earth. The main cycle was centered on a point displaced from Earth, depending on the planet. Furthermore, although the motion on the cycle was uniform, it was only so (equal angles in equal time) around the equant, a point at equal distance on the other side of the center of the circular

orbit as the center is from Earth.

As Julian Barbour emphasized in his brilliant book *The Discovery of Dynamics* (Oxford University Press, 2001), these features of the main cycles are just Johannes Kepler's first two laws, to first order in the eccentricity of the ellipse. An ellipse is a circle to first order. Earth and the equant are the two foci of the ellipse, and the uniform rotation about the equant (second focus) is Kepler's second law (equal areas in equal times about the first focus) to first order. That is, the Ptolemaic system was, in many respects, closer to our modern description of the heavens than was the Copernican, which eliminated the equant and off-center circle.

Copernicus explained one great puzzle of the Ptolemaic system. The angle of the Sun around its orbit, the angle of the epicycle center around the major cycle (circular orbit) of the inner planets, and the angle of the outer planets in their epicycle were all the same at all times.

Copernicus recognized that if one scaled all the orbits appropriately, and made the Sun rather than Earth the center, then all those cycles with identical angles disappeared, leaving the planets in much simpler orbits around the Sun. That scenario also created a solar orbit for Earth around the Sun. The collapse of the number of parts of the orbits was the great advance. In achieving it, Copernicus had established a relative scale for the whole solar system.

But with that step forward, Copernicus took at least one large one backward, from our point of view. He got rid of the baggage of the offset orbit center and the equant and thereby destroyed the ellipticity of the Ptolemaic orbits. He thus had to introduce additional epicycles to explain what the Ptolemaic system explained automatically. Had he retained the equants, the Copernican system would have been simpler, with fewer epicycles than the Ptolemaic. It was 60 years before Kepler, in positing his elliptical orbits, restored and improved on the equants.

One could even argue that the centrality of Earth in the Ptolemaic system followed naturally from observation. If Earth moved, one would expect the stars, if they were bodies at different distances from Earth, to exhibit parallax. To the naked-eye accuracy of about one minute of arc, no stellar parallax is visible. Is it more sensible to postulate that the stars are at least a million times farther away than the Sun, or that Earth does not move? The latter, as emphasized by

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