

Since nothing prevents the Earth from moving, I suggest that we should now consider also whether several motions suit it, so that it can be regarded as one of the planets. For, it is not the center of all the revolutions.

Nicolaus Copernicus

Nicolaus' Revolution

In this module, we'll explore how the characters of Copernicus, Tycho, Kepler and Galileo overturned the Earth-centered model that had dominated thinking for 1,600 years or so.



Nicolaus Copernicus put the Sun, not the Earth, at the center of the universe. The image on the right there is a famous one in astronomy. Its idea has been drilled into your head since kindergarten.

In addition to its aesthetics, as opposed to the complicated motion of circles on circles that was needed for the the Earth-centered model, this model allowed Copernicus to discover the difference between different types of periods. Between the Sidereal Period, the true period of how long it takes an object to go around, versus what the period looked like, the Synodic Period.

We explored this when we covered the Moon. We had the true orbital period at 27.3 days and how long it takes to go from full Moon to full Moon of about 29 days.

He was able to obtain the relative distances to the planets. In other words, how much farther is Mars from the Sun than Earth and how much farther is Jupiter than Mars?

Although it was beautiful, and simpler, **it did not work any better** than the Earth-centered model. This is basically because he held to the belief that the heavenly bodies must follow perfect circles.



Credit: University of Oxford, Public Catalogue Collection

It was really difficult to tell the difference between the geocentric model and a heliocentric model, because the quality of the data was just not good enough to be able to tell which model was right. Circa the mid-1500s or so, there was a rather colorful Danish nobleman by the name of Tycho Brahe who set out to correct this problem. Colorful enough to be known by only his first name, Tycho - no last name needed to identify this gent!

The image above shows Tycho standing next to a globe, and seated in the chair is King Rudolph. Tycho is petitioning the King for the funds to build a private observatory and make the most exquisite observations that have ever been done in an attempt to tell which one of these cosmological models was correct, a geocentric or a heliocentric model.

Tycho was successful in his funding quest. Below is an image of his private observatory, built on a private island. Private observatory on a private island. Nice gig. It was nicknamed after the muse of astronomy, Urania.

Also below is one of his instruments, a sextant. The image is to scale. So these were the largest metal measurement devices ever made. Beforehand they were all made out of wood, and so these were not only the first metal ones, but they were the largest metal ones ever made. And, of course, metal doesn't flex as much, doesn't bend as much, so you could get a lot more accurate grading on the sextant, for example, and measure angles a lot more accurately than you could with wood. Tycho's measurements remain the most accurate naked-eye observations ever made.



Uraniborg main building. Copper etching from Blaeu's Atlas Major, 1663.

Credit: Wikipedia Public Domain

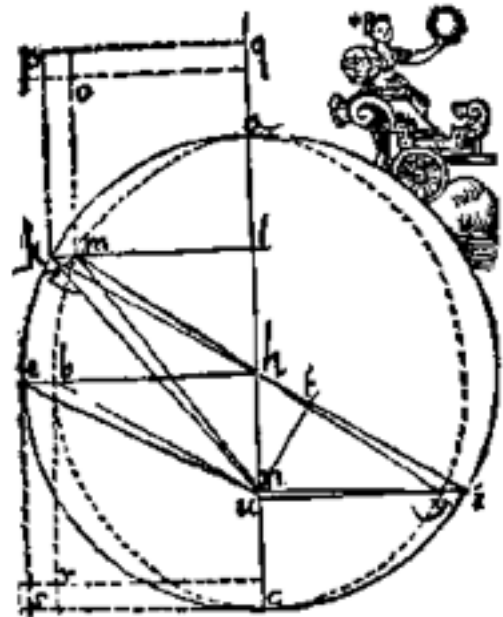


Tycho took some excellent data, but he really didn't know what to do with it. He was kind of this man in the middle between the geocentric model and the heliocentric model. He was an excellent observer, but he didn't quite know what to do with all the data. However, he had an assistant by the name of Johannes Kepler who did know what to do with it.

There are all kinds of great stories about Tycho, because he was a party animal. When he was 18-years-old, he got into a duel with another fellow over some obscure mathematical proof. And so they had this duel with swords, and Tycho ended up getting his nose chopped off. Undeterred, he had a silver nose fashioned and he went through the rest of his life wearing a silver nose. Tycho died because he ate and drank so much that he basically choked on his own fluids. As he was lying on his deathbed after partying so hard, he gave all of his data to Kepler and asked Kepler to make sense of it so that "I may not have lived in vain."



Credit: Wikipedia
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Kepler worked very hard to find an orbit for Mars. The greatest difficulty was in matching the data to a circular orbit. Above is an image of Kepler on the left, and on the right are some of his geometrical constructions as he's trying to fit a circular orbit, the perfect Greek circular orbit, to Mars.

Kepler did find a circular orbit that worked. It got to about two arc minutes of accuracy, which was OK. But in a couple cases, the error was about four times bigger, it was about eight arc minutes. And so he writes that, "If I believed that I could have ignored these eight arc minutes, I would have patched up my hypothesis accordingly and gone on. But since that was not permissible to ignore that big of an error, it led to a complete reformation in astronomy."



Credit: Wikipedia
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Above is an artistic rendition of Kepler. Notice the book that he's looking at contains a shot of Copernicus and his sun-centered model. And on the wall is the Tychonian model, which is this hybrid between a geocentric and a heliocentric cosmology that Tycho was sort of the man in the middle.

Thanks. Bye Bye.