

Brahe, Kepler, and Galileo  
A Burst of Ideas  
Astronomy  
Lesson 6

*Tycho Brahe*

A Danish nobleman, Tycho Brahe (1546-1601), made important contributions by devising the most precise instruments available before the invention of the telescope for observing the heavens. Brahe was by all accounts an extremely colorful character. He allegedly challenged a fellow student to a duel with swords in a dispute over who was the better mathematician. Brahe's nose was partially cut off, and he was said to wear a gold and silver replacement upon which he would continually rub oil. He fell out of favor when a new King came to power in 1588, and moved to Prague shortly thereafter. This is of great historical significance because this move would eventually make Brahe's data available to Kepler, who went to Prague also to become Brahe's assistant. Brahe is thought to have died when he contracted a urinary infection while attending a banquet hosted by a baron in Prague in which he drank extensively but felt that etiquette prevented him from leaving the table to relieve himself before the host left.

Brahe was one of the best observational astronomers that ever lived. He made the most precise observations that had yet been made by devising the best instruments available before the invention of the telescope, and His observations of planetary motion, particularly that of Mars, provided the crucial data for later astronomers like Kepler to construct our present model of the solar system. Finally, Brahe calculated that if the Earth moved then the stars are at least 700 times farther away from Saturn than Saturn is from the Sun!!! Again, scientists at the time felt that God would never waste so much space, and therefore, the Earth must be the center of the Universe.

*Johannes Kepler*

Johannes Kepler was hired by Tycho Brahe to mathematically prove Tycho's geocentric model of the Universe. However, Kepler did not believe either Tycho or Ptolemy's model of the Universe since the mathematics was so ugly. Kepler shared the philosophy of the Greeks that mathematics is the language of God and that God would not have such a complicated explanation of the universe. So, Kepler started from Copernicus' heliocentric model of the Universe.

Kepler tried to refine Copernicus' model, but after years of failure, he was forced to face the fact that planets cannot orbit the sun in a circle. This idea went against the 2000 year-old Pythagorean paradigm that the orbits must be perfect circles. In fact, Kepler discovered that planetary orbits were ellipses with the Sun at one focus. This is now known as Kepler's First Law. To account for the planets' motion (particularly Mars') among the stars, Kepler found that

the planets must move around the Sun at a variable speed. When the planet is close to the Sun, it moves quickly; when it is farther from the Sun, it moves slowly. This was another break with the Pythagorean paradigm of uniform motion!

#### *Galileo Galilei (1564-1642)*

Because people were so used to thinking of Earth at the center of the universe, the heliocentric model was not widely accepted at first. However, it was truly the telescope that helped change this view, pun intended. The telescope was invented in the early, early 1600's, and it was Galileo who made it famous. Galileo Galilei built his own telescopes and first turned a telescope to the heavens in 1610—he made several striking discoveries. He found that the planet Jupiter has moons orbiting around it. This was the first evidence that objects could orbit something besides Earth. The Galilean moons are the four moons of Jupiter discovered by Galileo Galilei on January 7, 1610. They are the largest of the many moons of Jupiter and derive their names from the lovers of Zeus: Io, Europa, Ganymede and Callisto. He also discovered that Venus has phases like our moon does. The phases of Venus provided direct evidence that Venus orbits the Sun. Galileo's discoveries caused many more people to accept the heliocentric model of the universe. The shift from an Earth-centered view to a Sun-centered view of the universe is referred to as the Copernican Revolution.

#### *The Modern Solar System*

Today, we know that our solar system is just one tiny part of the universe as a whole. Neither Earth nor the Sun is at the center of the universe. However, the heliocentric model does accurately describe our solar system. In our modern view of the solar system, the Sun is at the center, and planets move in elliptical orbits around the Sun. We have also discovered other solar systems, with planets orbiting their own stars.

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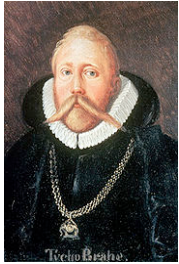


Johannes Kepler

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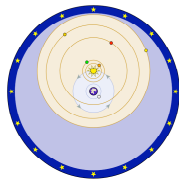
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Tycho Brahe

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Tychonian System of the Universe

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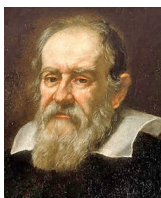
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Statue of Brahe and Kepler in Prague

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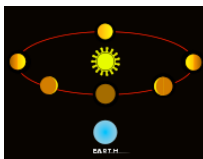
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Galileo Galilei

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Galilean Moons

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