

## Offered Title: Kepler Fixed the Universe

Copernicus was on the right track by putting the Sun at the center of our solar system. His idea was almost elegant. As with Ptolemy though, Copernicus's solar system relied on planets having epicycles. They revolved around the Sun, and at the same time circumscribed a smaller circle around a mysterious center of gravity. This was required to explain why planets seemed to travel backward (retrograde) some of the time, and periodically change speed. Copernicus's solution was still klutzy. What was the problem?

Orbits.

Copernicus, like his Greek predecessors, assumed planetary orbits were circular, a sign of perfection. After all, our solar system and universe beyond was perfect, no? No.

Twenty-eight years after Copernicus died, Johannes Kepler was born. Born into a strict Lutheran family, Kepler struggled a bit with the discrepancies between his data driven orbits and the church's (both Lutheran and Catholic) teachings. At that time, Copernicus's ideas had not been accepted by the church or other astronomers and his book banned. The philosophic environment regarding a heliocentric (Sun centered) solar system was mostly hostile.

Kepler apparently wasn't intimidated. After moving to Prague in 1600 Kepler became assistant to an already established and brilliant astronomer, Tycho Brahe. Their relationship was rocky but the lust for understanding our solar system's mechanics kept them working together. While Tycho was a brilliant observer and meticulous record keeper, he still resisted the idea of a heliocentric solar system and continued the concept of epicycles. On top of that, Tycho kept his data close to his chest, giving Kepler just a little at a time. Kepler struggled to fit Brahe's orbital data with epicycles and became convinced planetary orbits might not be circular. Imperfection? The horror! Then Brahe died only 18 months into their research partnership.

After Tycho's death, Kepler maintained communication with Tycho's family who also had a jealous hold on Tycho's data but provided Kepler limited access. Even with the dearth of observational data given him, Kepler was able to determine the Earth was moving! Earth had to be orbiting the Sun. The Sun was now central, epicycles thrown out, and Kepler gave planets elliptical orbits (stretched circles). These concepts (elliptical planetary orbits and Earth orbiting the Sun) solved the issues of retrograde and planets speeding up and slowing down. Based on its position in orbit and distance from the Sun a planet moves faster or slower, sometimes even appearing to move backward from another planet's perspective. This changed everything!

Tycho Brahe's data helped Johannes Kepler fix our universe, elegantly.

Kepler developed three laws of planetary motion: I elliptical orbit, II varying velocity III planetary distance and the Sun's force on it

These laws became the groundwork for all planetary orbital mechanics that followed.

## What's in the Sky?

08/24; pre-dawn; southeast: A waning crescent Moon is close to Aldebaran in Taurus

08/28; dawn; east: A thin waning crescent Moon is in M44 (the Beehive Cluster) in Cancer