Naked Eye Astronomy, Day 8: Completing the Copernican Revolution

1. Review
   (a) Please ask questions at ANY TIME.
   (b) Web page with resources for the course: `https://osp.berry.edu/SeniorScholars`.
   (c) Recall our previous discussions.
      i. Copernicus showed that the apparent motions of the stars, Sun, and five visible planets could be understood by assuming that all planets (including Earth) orbit around a stationary Sun in nearly a common plane, while Earth also rotates on an axis tilted 23.5 degrees relative to its orbital axis.
      ii. However, Ptolemy was also able to explain these same phenomena, but he did it without a moving Earth. A moving Earth contradicted common sense, Aristotelian physics, and some passages of Scripture, so most of Copernicus' contemporaries rejected the idea and stuck to Ptolemaic astronomy.
   (d) Now we will look at advances in astronomy and, especially, physics that led to the ultimate acceptance of a modified version of Copernicus' theory.

2. Kepler's Elliptical Astronomy
   (a) Johannes Kepler modified Copernicus' astronomy to use elliptical rather than circular orbits. (Show Kepler Planets simulation, increase eccentricity, discuss how planet speeds up and slows down to satisfy K's second law, location of Sun at focus.)
   (b) Kepler also suggested that the REASON planets moved this way was because they were pushed around by a force from the Sun. Although Kepler's physics was wrong (it was mostly Aristotelian), his idea that the motion of planets was governed by forces from the Sun was on the right track. This was the beginning of astrophysics. (Remember Kepler was the first person to draw a picture of the orbital MOTION of a planet in the Ptolemaic system.)

3. Galileo's Telescope and Inertia
   (a) In late 1609 Galileo heard about the telescope and made his own. He used his telescope to discover mountains on the moon, the "ears" (rings) of Saturn, four moons of Jupiter, and the phases of Venus.
   (b) Show predicted phases of Venus in Ptolemaic and Copernican system, plus Galileo's sketches. This killed the Ptolemaic system but not other models where Earth was stationary and other planets orbit around the orbiting Sun (Tychonic, etc).
   (c) Galileo also developed new ideas about motion. In particular, he made progress toward the idea of inertia: that objects already in motion will maintain their motion in a straight line at constant speed unless something messes with them. He used an idea like inertia to demolish the "tower argument" - that if Earth was rotating a stone dropped from a tower would land far to the west, when in fact it always lands at the base of the tower. Discuss how inertia solves this problem.

4. Newton's New Physics

   (a) The concept of inertia eventually led to a new view of orbital motion. To move in a circle an object must be continuously pulled TOWARD THE CENTER of the circle. Newton and Christiaan Huygens independently figured out how such centripetal forces must work. Orbital motion is a combination of inertia and a centripetal force. Show Central Force simulation.

   (b) Newton later realized that gravity, the same force that made an apple drop from a tree, might be what keeps the Moon in orbit around the Earth. He thought perhaps all objects attract each other in this way, and that could explain why planets orbit the Sun - it is a combination of their inertia and a gravitational attraction toward the Sun. He figured out how this force must behave and show that it could reproduce Kepler's elliptical orbits. Show Inverse Square Force simulation with circular, elliptical, parabolic, hyperbolic orbits.

   (c) Even before Newton's work, most astronomers had joined the Copernican side. After Newton's work made sense of Kepler's astronomy, pretty much everyone was convinced. But no DIRECT proof of Earth's orbital motion was found until the 1780s (aberration), then parallax in 1830s, Foucault pendulum for rotation in 1850s.

5. Questions and conversation