1 4/9/2024 lecture

The nearest star, Alpha Centaurus, is about 4.25 light-years away.

All planets orbit the sun in the same plane as the Earth. The Earth's axis of rotation is 23.5 degrees from being perpendicular to that plane. From the north's spring equinox (March 20) to the north's fall equinox (September 22), the southern hemisphere receives more radiation than the northern hemisphere, and the opposite is true for the other half of the year. The winter solstice, which marks the beginning of winter, is December 21 in the north and June 21 in the south. The summer solstice, which marks the beginning of summer, is June 21 in the north and December 21 in the south. The farther you are from the equator (the higher the absolute value of your latitude), the more dramatic your seasons are. In the arctic circle (¿67 degrees north) and the antarctic circle (¿67 degrees south), there is one day a year where the sun stays at the horizon.

An apparent path of the Sun through the sky on one day is called an ecliptic. The group of constellations which lie along the ecliptic is called the zodiac.

One reason people refused to believe the heliocentric model was because they could not observe parallax until the 1860s. In 1543, Copernicus used a heliocentric model to predict the distance of each planet to the sun, although he assumed all orbits are perfect circles. Tycho Brahe (1546-1601) compiled observation of planetary orbits accurate to about 1 arcminute, which motivated the invention of the telescope, helping to start the scientific revolution. Johannes Kepler (1571-1630) noticed tiny discrepancies in Brahe's observations which made Kepler suggest that orbits are elliptical.

Kepler's 1st law: The orbit of each planet around the sun is an ellipse, with the Sun at one focus.

Kepler's 2nd law: The rate at which the line segment from a planet to the sun sweeps out area is constant. In layman's terms, this means a planet's speed is inversely proportional to its distance from the sun.

Kepler's 3rd law: If p is the orbital period of a planet (in years), and a is the maximum distance to the sun (in AU), also called the semi-major axis of the ellipse, then $p^2 = a^3$.

Galileo Galilei (1564-1642) argued against the Aristotlean view of the heavens by (1) proving a moving Earth would not experience "wind" or cause us to feel noticeable force, (2) showing the heavens aren't perfect, because we can observe sunspots, and (3) claiming stars are way too far for us to observe any parallax. Newton's first law, which came later, also contradicted Aristotle's claim that moving objects will slow down without an external force.

Newton generalized Kepler's third law to say that for two bodies orbiting each other, if their masses are m and M, the period of their orbit is p, and the maximum distance between their centers is a, then

$$\frac{p^2}{a^3} = \frac{4\pi^2}{G(M+m)}.$$

If one of the masses is much larger than the other, you can approximate $M+m$ as the larger mass, M. This formula is very useful, because if we know p and a for the orbit of any comet, moon, or satellite about a much more massive object, we know the mass of the more massive object.