Lecture 1. If it moves then how do we know it.

1. Intro to class. and subject covered.
   - Solar system
   - Tools
   - Stars
   - Galaxy
   - Universe — is universe finite?

2. Back to Greeks.
   - Geocentric system — Ptolemy system

Q: Who believes that Earth is moving? Who does not?

The class goal is to remove believe from the equation.

Stellarium demo of stars and planet motions:

Observations: Stars seem to move in sync. Planets — wonder if star moves along and have retrograde motion

Epicycle: Planet

different circle
Magellan expedition 1519-1522

Copernicus (1473-1543) Geocentric

1543 - 1601

Kepler → elliptical motion

1609 book based on Mars

Tycho → accuracy

Galileo - 1608 telescope

to how to measure distances

Jupiter satellites Milky Way consist of stars
3. Q: How do we know that Venus and Mercury are closer to Sun?
A: We saw their transits over sun.

=> elongation

\[
\text{Venus} = 44^\circ
\]

Believe in the Earth is moving, we should feel it: wind blow etc.

4. Q: Proves that Earth rotates?
A: Foucault pendulum

5. Q: Does Earth move?

Cassini, mid 1650, Sun size difference 3.4%.

6. Halley, 1656 - 1742

1718 -> Compared to ancient star positions, with current => proper motion.

A: 7. Bessel, 1838, parallax of the stars

\[
61 \text{ Cygni} \Rightarrow 0.314'' \text{ updated to 0.318''}
\]

on a background of 5.2'' proper motion

1829 8. Bradley, aberration of light, due to finite speed of light
Q: How to measure distance to Venus based on transit?

Clocks: definition of the seconds

Use to be $\frac{1}{86400} = \frac{1}{24:00:00}$ of the mean solar day but it is not very stable due to Earth perturbations.

1 sec = 9,132,631,770 oscillations of Cs.

Solar year changes by 0.1 seconds per year.

Julian year = 365.25 days

Q: Which way Earth moves along its orbit

Solar day vs Sidereal day

Shorter by 4 min

1 in 10 per day = 4 minutes
Parallax

\[ \theta \approx 1 \Rightarrow \ell = \frac{d}{\tan \theta} = \frac{d}{\theta} \]

\[ R_E = 6.378 \times 10^6 \text{ m} \]

\[ 1 \text{ AU} = 1.4959 \times 10^8 \text{ km} \]

\[ 1 \text{ parsec} = \frac{1 \text{ AU}}{1^\circ} = \frac{1 \text{ AU}}{\frac{1^\circ}{3600}} = \frac{1 \text{ AU}}{\frac{1^\circ}{180} \times \frac{1^\circ}{3600}} = 206264 \text{ AU} \]

Q: Simple question if distance is 4 parsec
   is parallax 4 times bigger or smaller?
Amusement

* There is a rumor that Galileo's assistant was able to see phases of Jupiter and Venus with naked eye. Is it possible? pupil $\phi = 5 \text{mm}$

* Glasses lenses appear around 1280-1290

* Telescope patent 1608
  by Lipperhey (Dutch)

Galileo telescope August 25, 1609