

## Lecture 01

(P1)

1 Go over the syllabus

2 What is this class about? physics  
do not confuse with  
astronomy with a lot of fancy pictures

3 Believes vs fact check

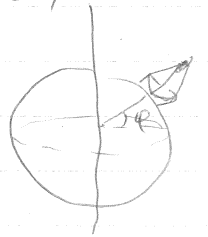
Q: Who believes that Earth rotates  
and moves around the sun?  
Who does not believe?

4 Address Earth rotation around ~~the~~  
its axis.

Surprisingly, solid proof of it came  
from the Foucault pendulum in 1851

$$\omega_{\text{plane motion}} = \frac{360^\circ \sin \phi}{1 \text{ day}}$$

and later with use of gyroscopes



5. Q: Ok. So what do we see when we look at star?

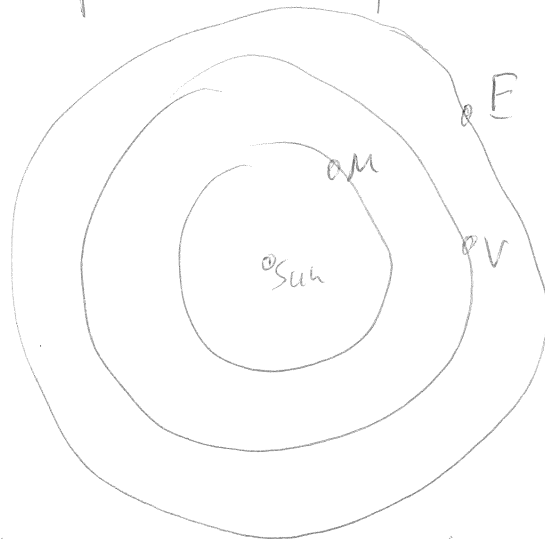
A: they moves seemingly in sync.

⇒ Earth center of rotation and universe! Geocentric system ⇒ Hipparchus ⇒ Hipparchus (150 ~~BC~~ BC)

6. What about retrograd motion?

Ptolemy (100 AD) - epicycles

7. Copernicus <sup>(1473-1543)</sup> with heliocentric model, published after his death



and so on

Note that Magellan's expedition dates are 1519-1522, i.e. we know that we can loop around Earth

Nice idea. But data does not support it (since perfect circles ~~is~~ are no good).

(P3)

Tycho Brahe (1546-1601) the best astronomer of that time criticized Copernicus' model on the following base.

No one see <sup>stars</sup> parallax while stars appear to have angular size (they did not know about diffraction then). So if we assume that Earth moves, the estimate of star sizes would be huge (larger than Earth orbit) so Sun seems to be a special small star. See 'pdf' link

Note the Brahe angular precision was about 4'

7a. Cassini in mid 1650 observe seasonal variation of the Sun, about 3.4% difference in angular size.

By itself it is not a proof of Earth motion. May be the sun just inflates/deflates with seasons

8. So if one observes a star parallax that would be a nice prove that Earth moves around sun.

But we need better tools to move beyond a naked eye resolution of 4'

⇒ telescope by Hans Lippershey in 1608

German-Dutch

Galileo was later (~1609).

Wonderful! Better resolution still no parallax. ☹️

But Galileo saw satellites around Jupiter which looks like "miniature" solar system model.

9. Halley (remember the comet?) (1656-1742) in 1718 compared ancient records with current and noticed that stars are moving with respect to each other. So called "proper" motion.

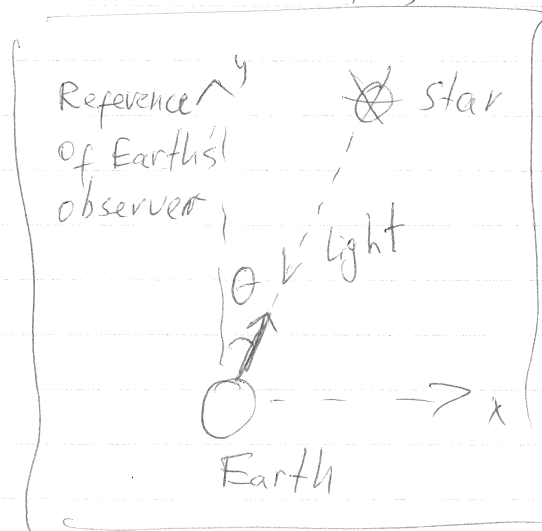
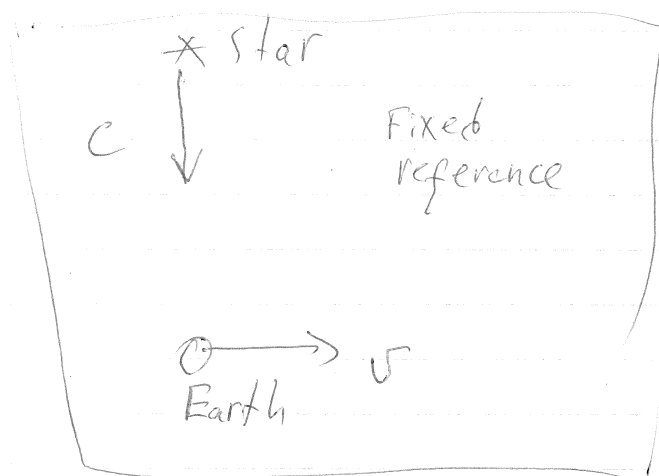
Yet no yearly "loops" in their position observation

10. 1729 James Bradley observe  
apparent motion of the  $\gamma$  Draconis (Eltanin)  
done with attachment of a telescope  
permanent and fixed

to a chimney of his house.

The motion was  $20''$ .

Can be explain classially (and was by Bradley)  
as ~~speed~~ addition of velocities vectors



$\theta = \frac{v}{c}$  / This days we know that  
Earth moves with  $v = 30 \frac{\text{km}}{\text{s}}$   
around the sun and  
speed of light  $c = 3 \cdot 10^8 \text{ m/s}$

$$\theta = \frac{30 \cdot 10^3}{3 \cdot 10^8} = 10^{-4} \text{ rad} = 10^{-4} \cdot \frac{360^\circ}{2\pi} \cdot \frac{3600''}{1^\circ} =$$

$\approx 20.6''$  (as observed by Bradley)

But this explanation was disregarded  
(did not fit those day theories).

11. So it took Bessel to observe the parallax of 61 Cygni (star with the largest known proper motion at that time).

---

in 1838 he reported  $0.314''$  parallax (modern value  $0.348''$ )  
on a background of  $5.2''$  of proper motion

---

So since 1838 we have a solid prove that Earth is not the center of universe and moves around the Sun.