# Special Relativity

## (1) speed of light (c) is finite

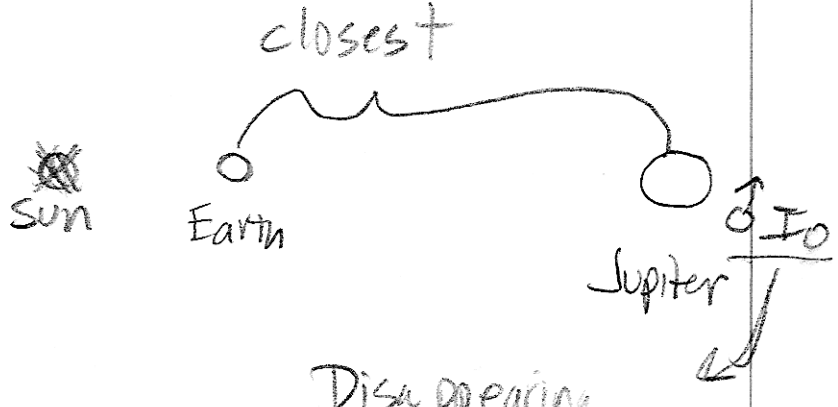
(a) First measured in 1676 by Ole Rømer, a Dane living in Paris. He used the orbits of the moons of Jupiter as a clock.

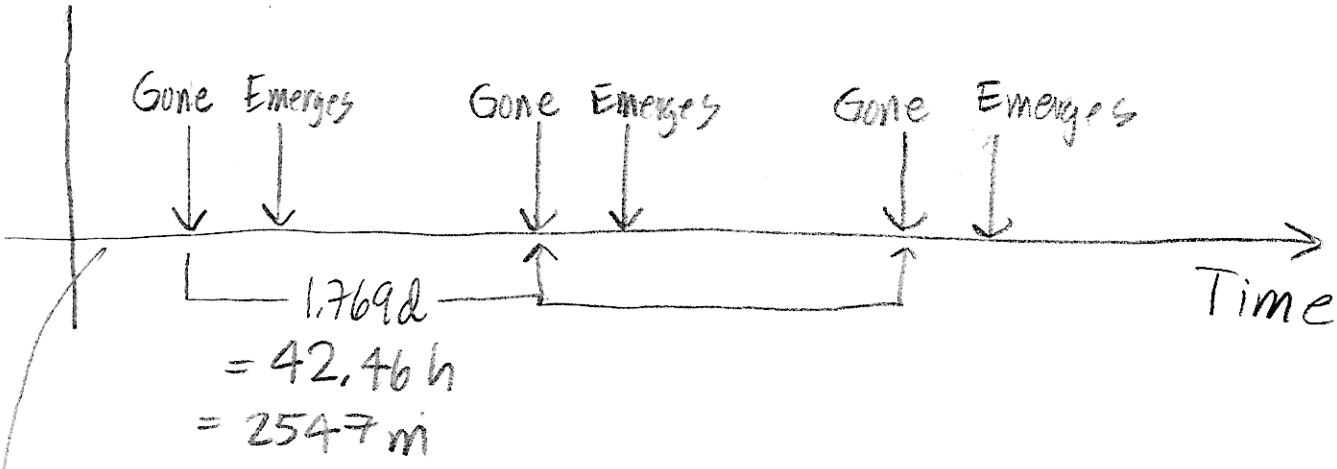
### Large Moons of Jupiter

| Name | Period | Diameter |
|---|---|---|
| Io | 1.769 days | 3630 |
| Europa | 3.551 | 3138 |
| Ganymede | 7.155 | 5262 ← Largest moon in Solar System, Larger than Pluto & Mercury |
| Callisto | 16.689 | 4800 |

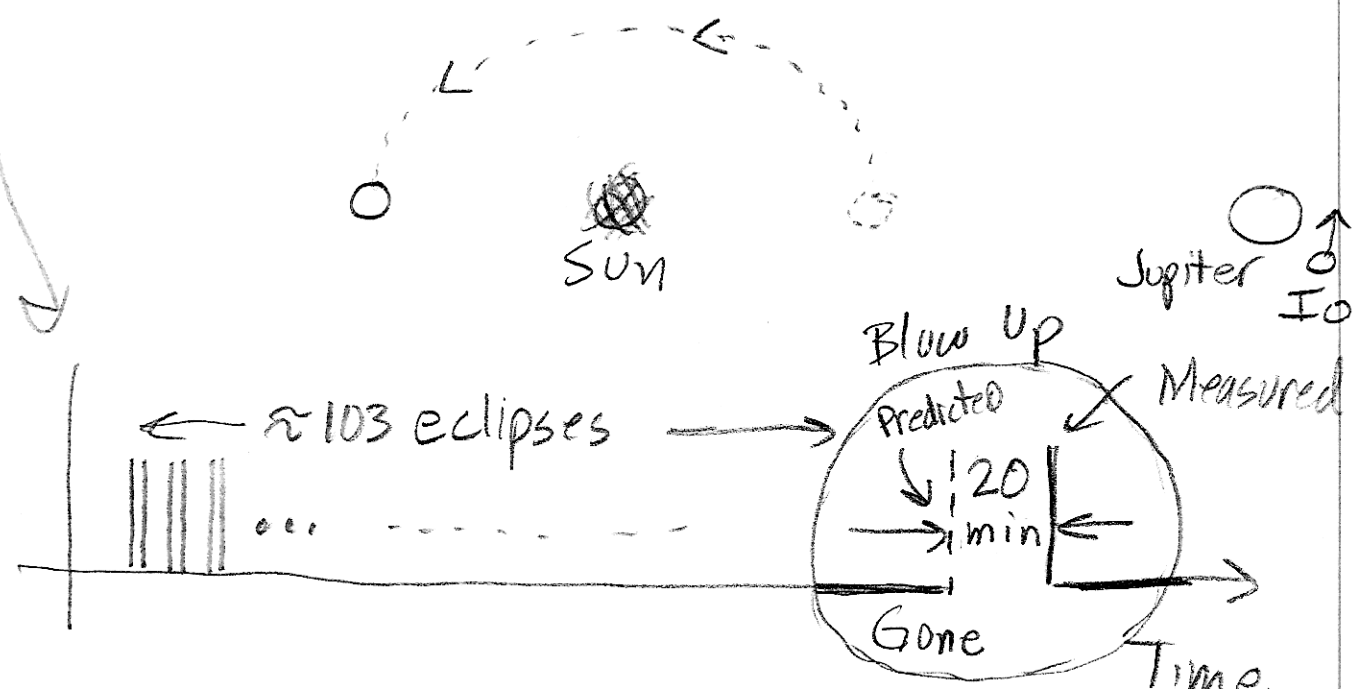
Earth (12,756 km) (Our Moon 3476 km)

Imagine measuring <u>when</u> Io <u>goes behind</u> Jupiter and then <u>when</u> Io <u>emerges</u>. Start when Earth + Jupiter are <u>closest</u>:






Jupiter takes 11.9y to orbit sun. Earth 1 year, So Jupiter almost "Stands Still"
So, ½ year later, situation is:




Io passes behind Jupiter (when earth far from Jupiter) about 17 minutes later than expected (Roemer actually got 22 minutes)

Diameter Earth's Orbit = 2 A.U.

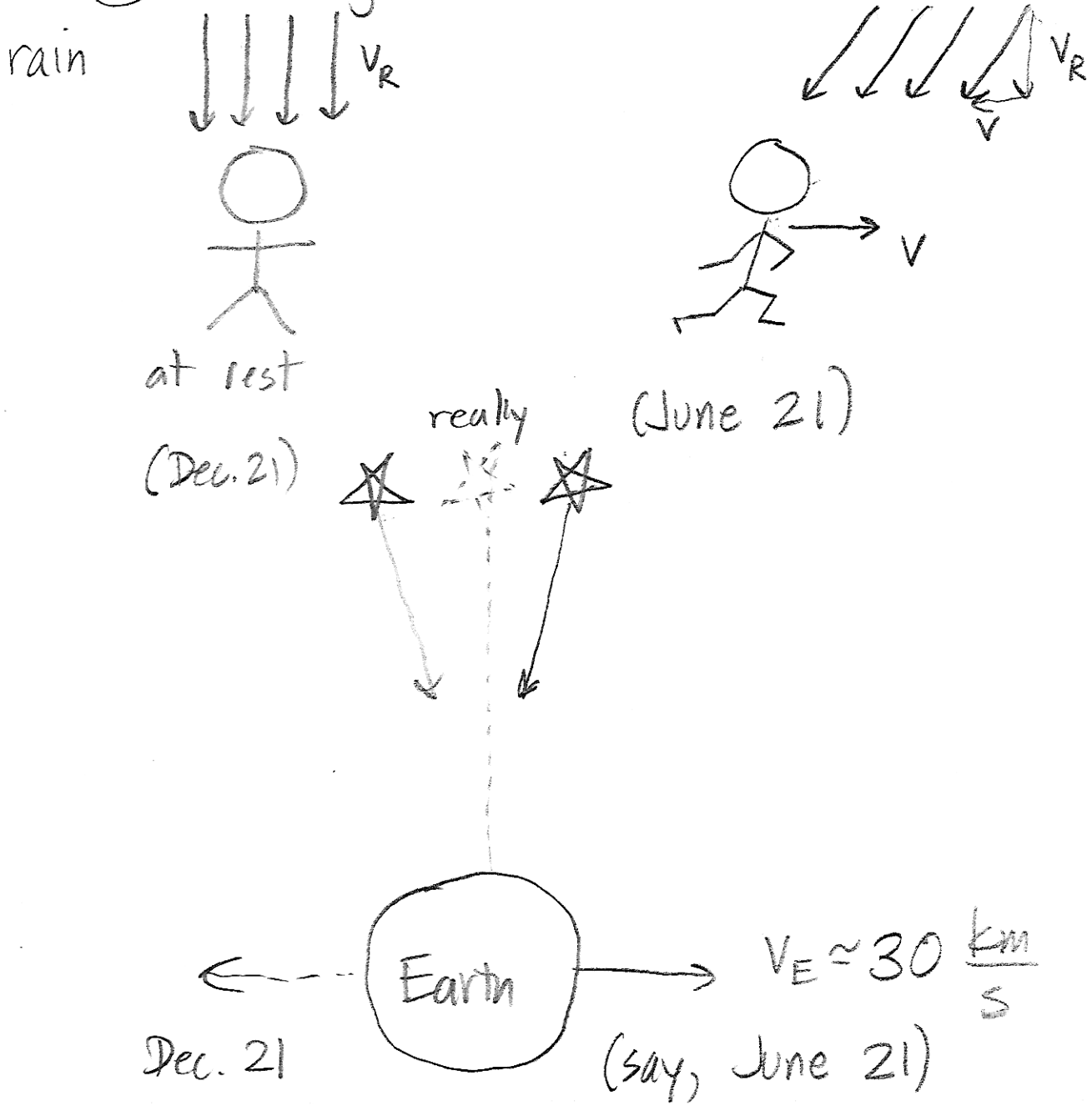
$2AU = 2 \times 1.5 \cdot 10^8 \text{ km} = 3 \cdot 10^8 \text{ km}$

17 minutes $\simeq 10^3$ seconds.

$$c \simeq \frac{3 \cdot 10^8 \text{ km}}{10^3 \text{ s}} \simeq 3 \cdot 10^5 \text{ km/s}$$

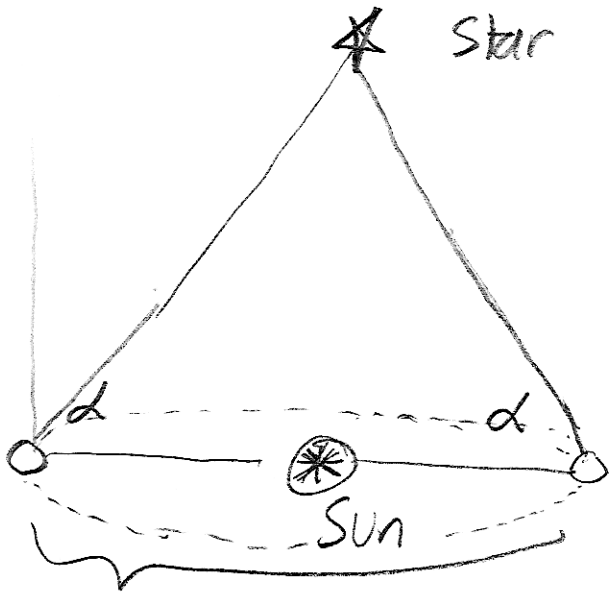
(Rømer got $2 \cdot 10^5$ km/s)

(b) Running into the rain... of light



Called the "aberration of starlight," first noted in 1727 or so by James Bradley in England.

What was he <u>really</u> trying to do? Estimate the distance to a star by parallax...




If α well measured, one side known, can reconstruct distance to star...

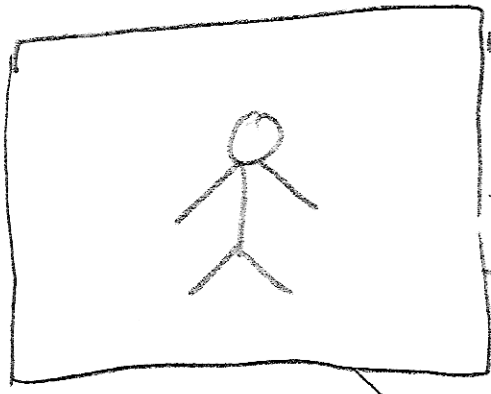
Nearest Bright Star → α Centauri, 4.3 light years away.

$$= 4.3y \times 3 \cdot 10^5 \frac{km}{s} \times (\pi \times 10^7) \frac{s}{y}$$

$$D_\alpha = 4.3 \cdot 3 \cdot \pi \cdot 10^{12} \frac{km}{s} = 4 \cdot 10^{13} \text{ km}$$

$D_{sun} = 1.5 \cdot 10^8 \Rightarrow$ next star $\approx 3 \cdot 10^5$ further than sun.

(2) Unless you can see external objects, there is no way to tell if you are moving with a constant velocity (however fast).

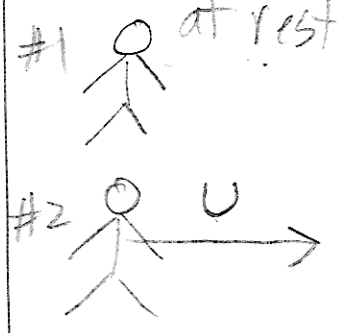



For example:

2 clocks of different mechanisms (one mechanical, one electronic..) must run the same!

(as long as $\frac{d\vec{v}}{dt} = 0$!)

(3) (The biggy!) Light always appears to move at the speed c, in a vacuum, no matter how fast you move!!!





sees flash of light moving away at c too! (!!!)

not: c − v!