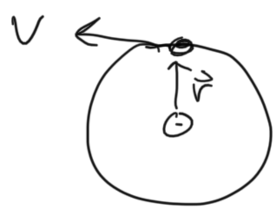
ASTR 3070 - Week 02a (Earth Moves)

Why don't we notice the centrifugal accel. of Earth's rotation?

$$\vec{a}_{cen} = \vec{\omega} \times \underbrace{\underbrace{(\vec{\omega} \times \vec{r})}_{\text{same dir. as } \vec{v}}}_{\text{same dir. as } \vec{r}}$$



$$|\vec{a}| = \omega^2 r \,, \quad r = R_E \;\&\; \omega = \frac{2\pi}{1d}$$

$$R_E = 6400\,\text{km} \,, \quad 1\,\text{yr} \simeq \pi \times 10^7\,\text{s}$$

$$\omega \simeq \frac{2\pi}{1d}\left(\frac{365.25\,d}{yr}\right)\left(\pi \times 10^7 \frac{s}{yr}\right)^{-1}$$

$$= 2 \times 10^{-7} \cdot 365.25\ s^{-1} = \underline{7.3 \times 10^{-5}\ s^{-1}}$$

$$|\vec{a}| = \omega^2 r = (7.3 \times 10^{-5}\,s^{-1})^2 (6.4 \times 10^6\,m)$$

$$= 7.3^2 \cdot 6.4 \cdot 10^{-4}\ m\,s^{-2}$$

$= 3.4 \times 10 \; m s \;= 0.034 \; m s$

$$|\vec{a}_g| = 9.8\,ms^{-2}$$

$$\frac{|\vec{a}_{cm}|}{|\vec{a}_g|} \sim 0.3\%$$

My weight would change by $\sim \frac{1}{2}$ lb b/t the poles & equator $\rightarrow$ less than it changes over the course of a day due to changes in water weight!

Rotation causes $\sim 500\,m/s$ (1000 mph) motion @ equator, but Earth also moving around the Sun $(|\vec{v}| = \omega r)$

$$v_E = \omega R_s = \frac{2\pi}{1yr} \cdot 1AU$$

$$AU \equiv 1.496 \times 10^{11}\,m$$

$$v_E = 2 \cdot 1.5 \times 10^{-7+11}\,m/s = 3 \times 10^{4}\,m/s$$

~ 30 km/s

Faster than rotation, but corresp.

$$|\vec{a}_{cen}| = \omega^2 R = 2^2 \cdot 1.5 \cdot 10^{-14+11}\ \mathrm{m\,s^{-2}}$$

$$= 0.006\ \mathrm{m\,s^{-2}} \sim 5\times \downarrow \text{ than rot}$$

But, easy to detect with accurate telescope pointing: <u>aberration of starlight</u>

Earth frame

$$\tan\theta = \frac{v}{c} = \frac{30\ \mathrm{km/s}}{3\times 10^5\ \mathrm{km/s}} = 10^{-4}\ \mathrm{rad}$$

$\theta \ll 1$, $\tan\theta \simeq \theta$

$$\theta = 10^{-4}\ \mathrm{rad} \cdot \underbrace{\frac{180^\circ}{\pi\ \mathrm{rad}} \cdot \frac{60'}{1^\circ} \cdot \frac{60''}{1'}}_{\underline{206265}\ \mathrm{arcsec/rad}}$$

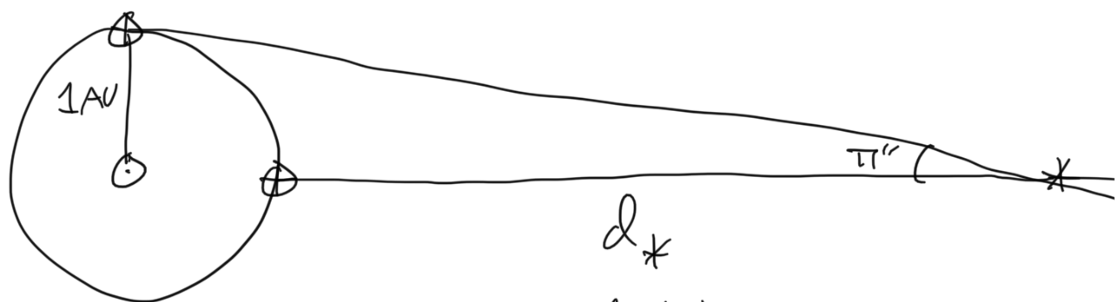
$\theta \simeq 20''$, eye is $\sim 1'$, so need telesc

1st measured in 1680 by Jean (Luc?)

′ Picard

Many 1m class telescopes have 1″ resoluti
(b/c on Earth) & a few arcmin FOVs,
so effect often not important in practic.

One reason Tycho & others didn't think
the Earth revolved around the Sun
was the lack of parallax



$$\tan \pi'' = \frac{1\,AU}{d_*} \simeq \pi''$$

$$d_* = \frac{1\,AU}{\pi''(rad)} = \frac{206265}{(\pi''/arcsec)}\,AU$$

If 2′ is needed to measure parallax
by eye, stars must be farther
than $d_* = \frac{206265\,AU}{120''}$ ~ 2000× farther than the sun

Nearest star proxima cen has $\pi'' = 0.76$

way smaller than aberration!

If this how astronomers measure distance

why not use it as a new unit?

Define $1\,\mathrm{pc} = d(\pi'' = 1'')$

parsec $\equiv$ parallax-arcsec

$$1\,\mathrm{pc} = 206265\,\mathrm{AU} = 3.086 \times 10^{16}\,\mathrm{m}$$

$$= 3.26 \text{ light-years}$$

Kepler's 3rd law $\quad p^2 = a^3$

Is this a proper equation?

Nope: MUST include units

$$\left(\frac{p}{1\,yr}\right)^2 = \left(\frac{a}{1\,AU}\right)^3$$

What is an AU? $\quad a_E$

Can move the units

$$p^2 = \underbrace{\frac{(1\,yr)^2}{(1\,AU)^3}}\, a^3$$

define to be a const K

$K = 1\ yr^2/AU^3 \rightarrow p^2 = K a^3$

Works outside the solar system, but
the value of K will be different