TEST Thursday
come ~5m early if possible
OPEN BOOK, NO ELECTRONICS
last yrs test on-line
(also problem sets & section exercises)

REVIEW SESSIONS
Weds 6:30 - 7:30 TBD
9:15 - 10:00 WLH 208

ALSO TF office hrs
classes server (before 10pm)

# TRANSITS

light blocked by planet

must be edge on


depth of transit (fraction of light observed)

$$\rightarrow \frac{\text{cross-section planet}}{\text{cross-section star}} = \frac{\pi R_p^2}{\pi R_*^2}$$

Example: Earth transiting Sun

$R_\oplus = 7 \times 10^6$ m

$R_\odot = 7 \times 10^8$ m

$$\text{depth} = \left(\frac{R_\oplus}{R_\odot}\right)^2 = \left(\frac{7\times10^6}{7\times10^8}\right)^2 = (10^{-2})^2 = 10^{-4}$$

0.01%

transit → radius } ⇒ density
Doppler → mass }

$M_E = 6 \times 10^{24}$ kg

$R_E = 7 \times 10^6$ m

$$\rho = \frac{\text{mass}}{\text{volume}} = \frac{M}{\frac{4}{3}\pi R^3}$$

$$= \frac{6 \times 10^{24}}{4 \times (7 \times 10^6)^3}$$

$7 \times 50$
$= 350$

$$= \frac{6 \times 10^{24}}{4 \times 350 \times 10^{18}}$$
$1,400$

$$= \frac{6 \times 10^{24}}{1.4 \times 10^{21}} = 4 \times 10^3 \text{ kg/m}^3$$

$10^3$ kg/m$^3$
= water

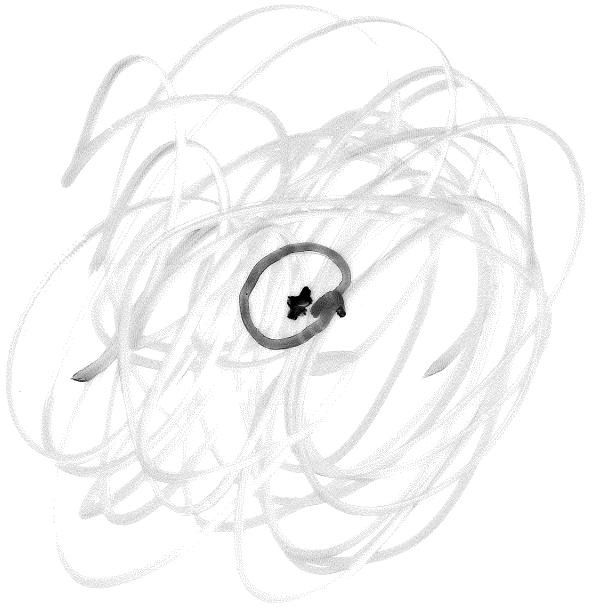
$= 4 \times$ water

⇒ Rocky

# ANOTHER METHOD
(astrometry)

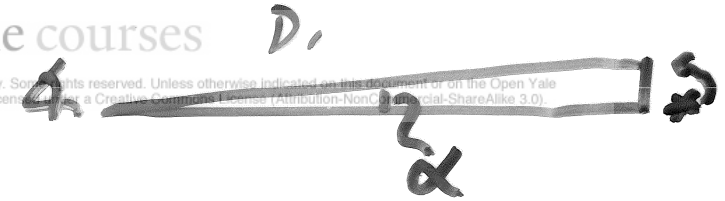
observing change in position of star

Key point: determine center of a blob right to much greater accuracy than extent of blob



exercise:
how big a change in Sun's position due to Jupiter would an (Ideal) astronomer observe.

"change in position"




want angular change

$M_\odot = M_\odot$

$M_J = 2 \times 10^{27}\ kg = 10^{-3} M_\odot$

$D_{\alpha Cen - \odot} = 1\ pc$

$a_J = 5\ A.U.$

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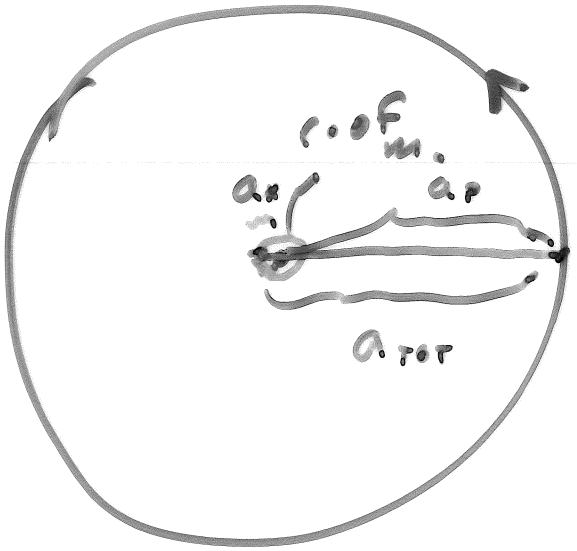


$M_* a_* = M_p a_p$

$a_* = \frac{M_p}{M_*} a_p$

$= 10^{-3}\ 5\ AU$

$= 5 \times 10^{-3}\ AU$

$\alpha = \frac{D_2}{D_1}$ (D₂ ~ AU)

$= \frac{5 \times 10^{-3}}{1}$

$\alpha$ → arc second

$D_1$ → 2 → parsec

$= 5 \times 10^{-3}$ arc seconds

OBSERVABLE



WE DON'T OBSERVE THIS IN $\alpha$ Cen

Ex: Earth: $a_p = 1\,AU$.

$M_p = 6 \times 10^{24}$

$$\frac{M_p}{M_*} = \frac{6 \times 10^{24}}{2 \times 10^{30}} = 3 \times 10^{-6}$$

$$a_{\odot\,(Earth)} = 1\,AU \times 3 \times 10^{-6}$$

$3 \times 10^{-6}\,AU$

$$\alpha = \frac{D_2}{D_1} = \frac{3 \times 10^{-6}}{1} = 3 \times 10^{-6}\ \text{arcsec}$$

NOT OBSERVABLE

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<u>astrometry</u>: favors BIG orbits

opposite of radial vel.

favors massive planet

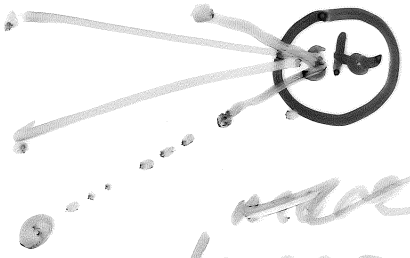
<u>same</u> as radial vel.



$\Rightarrow$ star needs to be nearby

# SELECTION EFFECTS

| method | orbits | planets | other |
|---|---|---|---|
| radial velocity (Doppler) | short/small | massive | help to be close to edge-on |
| transits | short/small | large | MUST be edge-on |
| astrometry | large | massive | must be nearby |




~~more~~ obl
larger a
makes it harder
to have a
transit

"microlensing"