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
obscured)

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

example: Earth transiting Sun

$$R_e = 7 \times 10^6 \, m$$
$$R_* = 7 \times 10^8 \, m$$

$$\text{depth} = \left(\dfrac{R_e}{R_*}\right)^2 = \left(\dfrac{7 \times 10^6}{7 \times 10^8}\right)^2 = (10^{-2})^2$$
$$= 10^{-4}$$

$$0.01\%$$

transit → radius } ⟹ density
Doppler → mass }

$$M_E = 6 \times 10^{24} \text{ kg}$$
$$R_E = 7 \times 10^6 \text{ m}$$

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

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

$$7 \times 50 = 350$$

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

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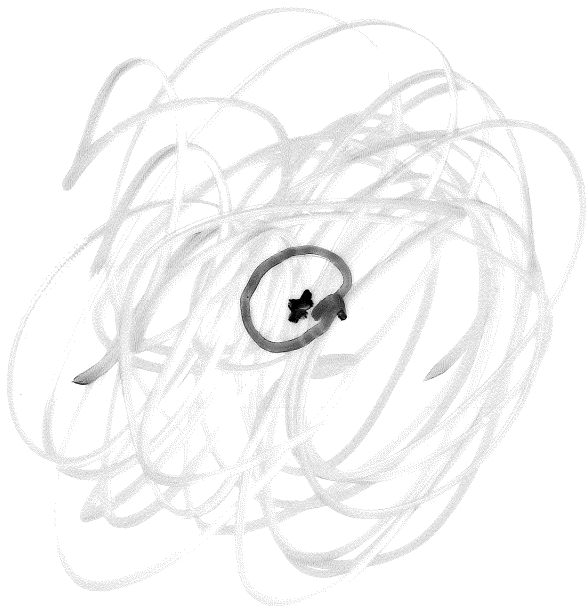
water

$4 \times$ water
⟹ Rocky

ANOTHER METHOD
(astrometry)

observing change in position of
star

key point: determine center of
a blob light to much
greater accuracy than extent
of blob

exercise:

how big a change
in Sun's position
due to Jupiter
would an
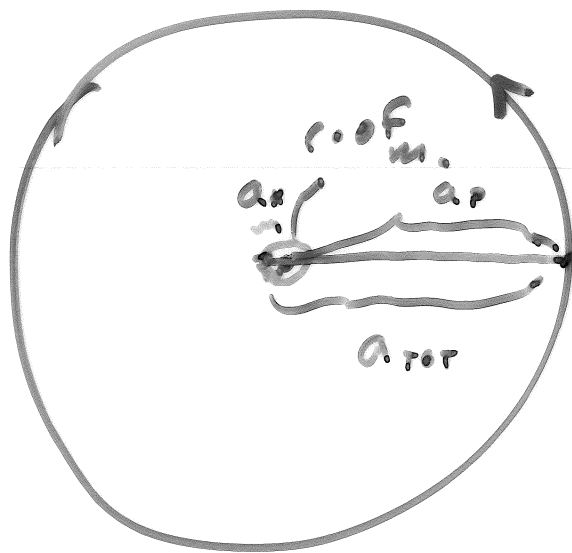α Cen astronomer
observe.

"change in position"

$$\frac{D_1}{2} \approx D_2$$

want
$$\frac{angular}{change}$$

$$M_\odot = M_\odot$$

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

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

$$a_J = 5 A.U.$$

$$M_\star a_\star = M_p a_p$$

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

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

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

$$\alpha = \frac{D_2}{D_1} \rightsquigarrow AU$$

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

arc second

$\rightsquigarrow$ parsec

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

OBSERVABLE

WE SHOULD OBSERVE THIS IN
α Cen

ex. Earth: $a_p = 1$ AU.

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

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

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

3×10^{-6} AU

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

NOT OBSERVABLE

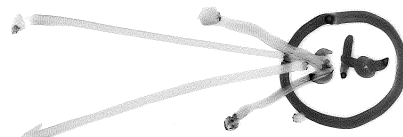astrometry: favors BIG orbits

opposite of radial vel.

favors massive planet
same as radial vel.

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

&

larger a makes it harder to have a transit

"microlensing"