

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 WLN 208

ALSO TF R 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

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

$$R_* = 7 \times 10^8 \text{ m}$$

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

0.01%

transit \rightarrow radius } \Rightarrow density
 Doppler \rightarrow mass }

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

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

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

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

$$\begin{aligned} 7 \times 50 \\ = 350 \end{aligned}$$

$$= \frac{6 \times 10^{24}}{4 \times 350 \times 10^{18}} = \frac{6 \times 10^{24}}{1400 \times 10^{18}}$$

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

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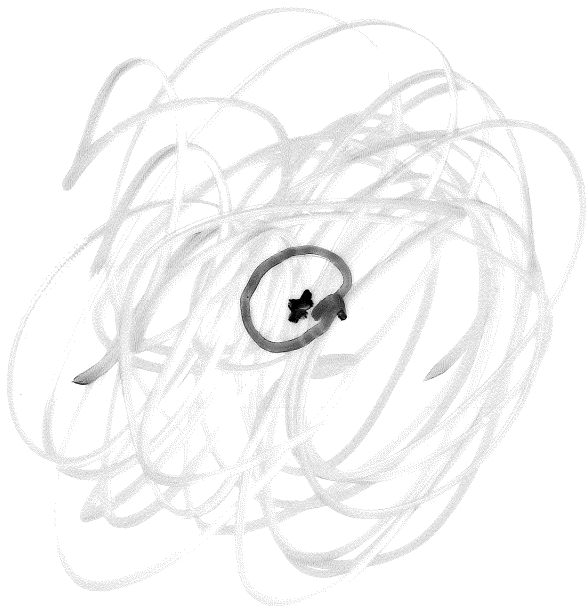
4x water

\Rightarrow 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 alien astronomer observe.

"change in position"

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D_1

D_2

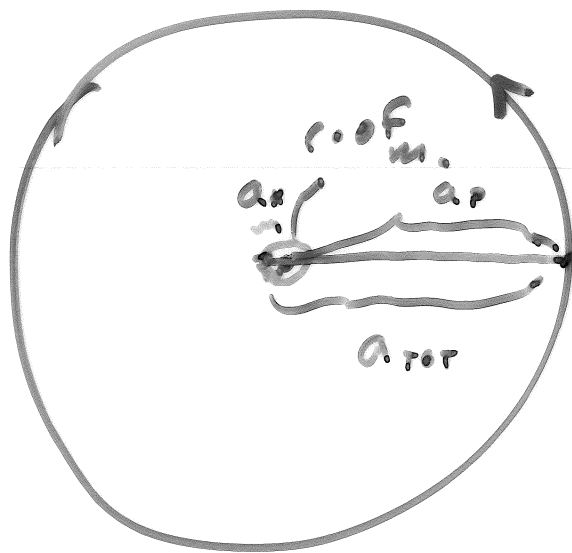
want
angular
change

$$M_{\odot} = M_{\odot}$$

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

$$D_{\text{Jup}-\odot} = 1 \text{ pc}$$

$$a_J = 5 \text{ A.U.}$$



$$M_* a_* = M_p a_p$$

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

$$= 10^{-3} \text{ SAU}$$

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

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

$$\alpha = \frac{D_2}{D_1} \begin{matrix} \nearrow \text{AU} \\ \searrow \text{parsec} \end{matrix}$$

arc second

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

OBSERVABLE

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**OBSERVE THIS IN
α Cen**

Earth: $a_p = 1 \text{ AU}$
 $M_p = 6 \times 10^{24}$

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

$$a_0 (\text{Earth}) = 1 \text{ AU} \times 3 \times 10^{-6} = 3 \times 10^{-6} \text{ AU}$$

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

NOT OBSERVABLE

astrometry: favors BIG orbits

opposite of radial vel.

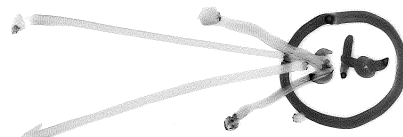
favors massive planet
same as radial vel.

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

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larger a
makes it harder
to have a
transit

"microlensing"