Exo-Solar Planet HD209458b

Exercise 3:

In this exercise we will use the equation for a "single-line spectroscopic binary with a low mass secondary" (an extra-solar planet), the measured projection of the orbital velocity from the velocity curve, information about the primary or parent star (HD209458a) as determined by its spectral type, and the period determined from the light curve (HD209458b was the first known "transiting extra-solar planet") to determine the "m sin(i)" of the planet. Using the inclination of the orbit as determined from the transit light curve, determine the true mass of the planet. Then by estimating the "depth" of the transit light curve (using transit data from measurements made from NGAO), determine the diameter of the extra-solar planet and finally its mean density. Should this planet be classified as a "Jovian" or "Terrestrial" world?

$m \sin(i) = [(1/30)(M^2T)]^{1/3} v_r$ "textbook version" of equation to determine "m sin(i)" of the planet;

m = mass of planet, M = mass of parent star (masses in $M_\odot$)
v_r = radial or projected orbital velocity (from velocity curve) (km/s)
$T \equiv$ orbital period (years)

$R_p = R_{star}(1 - 10\text{^}[-\Delta m/2.5])^{1/2}$ equation developed in class to determine the relative planet radius to the parent star radius using the transit "depth" in mags
Δm = "transit depth" in mags (positive value)

$\rho = m/V$ mean density of planet, m = mass of planet (kg), V = volume of planet (m^3)

Data, Constants, & Conversions:

$M_\odot = 1048\ M_J = 1.9891 \times 10^{30}$ kg $\quad$ $M = 1.13\ M_\odot$ (mass of parent star HD209458a)

$R_{star} = 1.14\ R_\odot$ $\quad$ $R_\odot = 9.74\ R_J$ (R_J = Jupiter radii) = 696265 km

v_r = 84 m/s (radial or "projected" orbital velocity – known as the semi-amplitude in the vel curve)

T = 3.5247 days (best determined from light curve) $\quad$ Δm = determine from light curve plot

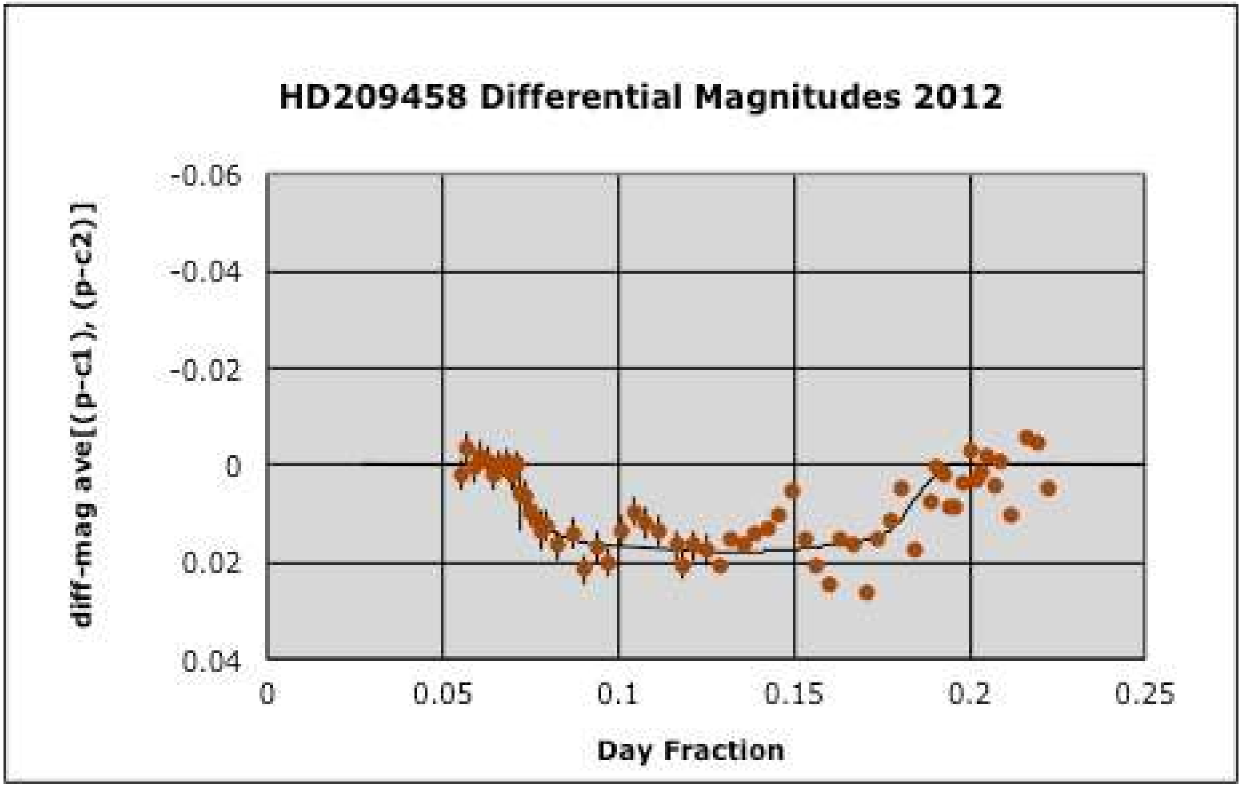
$i = 86^o$ (inclination of the planet's orbit – determined from light curve, use to find sin(i))

See light curve (NGAO) & radial velocity curve (Mazeh, et al. 2000) next page

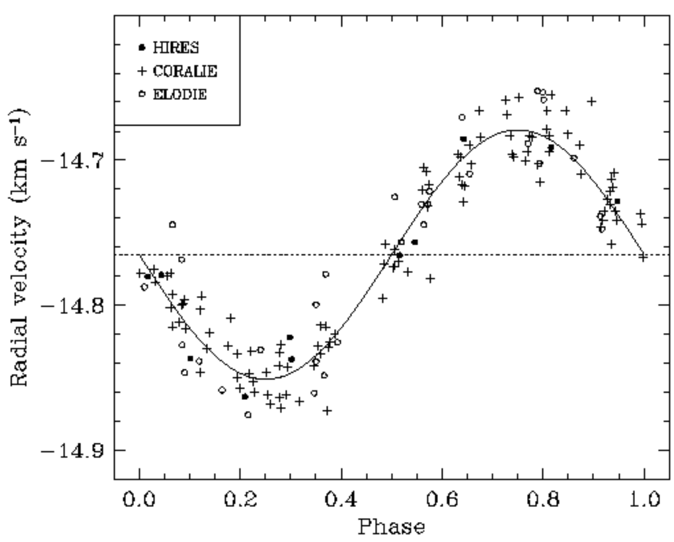
Determine the mass of the planet in Jupiter masses (M_J)

Determine the radius of the planet in Jupiter radii (R_J)

Determine the mean density of the planet in kg/m^3
(Note: ρ(Earth) = 5513 kg/m^3 $\quad$ ρ(Jupiter) = 1330 kg/m^3) – Is the planet more like a Terrestrial or Jovian world?



Estimate maximum “depth” in magnitudes; line is not a true fit, so don’t necessarily use it for your estimate.



Velocity curve from Mazeh et al. 2000