# Meteo 466: Homework #8

(Due: Wednesday, April 25)

In a 1-planet system, the planet and the star both orbit the center of mass of the system in elliptical orbits. Assume for simplicity that the eccentricity of both orbits is zero, so that both the planet and the star move in circular paths. Assume also that the star is much more massive than the planet, so the planet's mass can be neglected relative to that of the star. Do all calculations *approximately*.

1. Suppose that the system in which you are interested is Jupiter orbiting around our own Sun. Find the center of mass (CM) of the system, *i.e.*, identify the distances a_s and a_p in the diagram below:
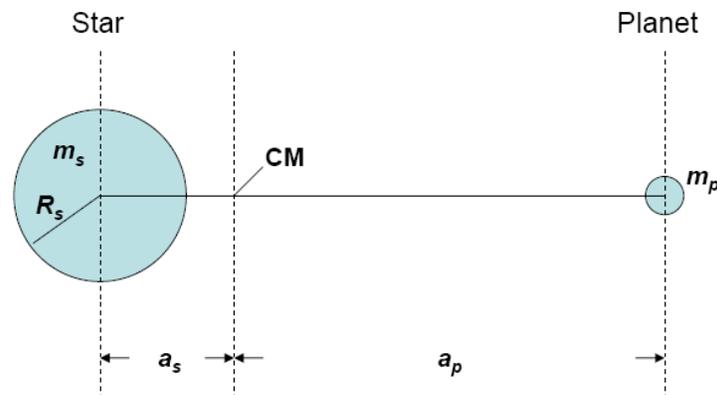
Data: $a_p = 5.2$ AU (Jupiter's semi-major axis)
$m_p \cong 0.001\ m_s$ (Jupiter's mass vs. Sun's mass)
$R_s \cong 7 \times 10^5$ km (Sun's radius)
1 AU $\cong 1.5 \times 10^8$ km
1 pc $= 3.086 \times 10^{13}$ km
2π radians $= 1.296 \times 10^6$ arcseconds

2. a) By how much would the position of the Sun change during a full Jovian year? How does this distance compare to the Sun's radius?
   b) By what angle would the Sun appear to move if one was observing the system from a distance of 10 pc? Express your answer in mas (milliarcseconds).

3. What are the equivalent answers to question 2 if the planet is Earth (orbiting at 1 AU) instead of Jupiter? Assume that Earth's mass is approximately 1/300$^{\text{th}}$ that of Jupiter.

4. Find Jupiter's orbital velocity and its period. (<u>Hint</u>: Set the centripetal acceleration equal to the gravitational attraction by the Sun. Or use Kepler's 3$^{\text{rd}}$ law.)

(over) $\Rightarrow$

Data: $m_s = 2.0 \times 10^{30}$ kg (Sun's mass)
          $G = 6.67 \times 10^{-11}$ m^{3}kg^{-1}s^{-2} (gravitational constant)

5. Find the Sun's orbital velocity around the center of mass. To do so, use the fact that the Sun must orbit the center of mass in the same amount of time as does Jupiter, or simply use conservation of linear momentum within the system. Would this motion be detectable by modern RV (radial velocity) techniques? The current limit for RV detection is ~1 m/s for most stars.

6. Now suppose that the planet is a "hot Jupiter" with a semi-major axis of 0.04 AU. Repeat problems 4 and 5 for this planet.

7. Repeat the calculations of problems 4 and 5 for Earth (at 1 AU). Would Earth be detectable, given current technology?