**51 Peg’s Planet**

Reproduced below is a plot of observations of the radial velocity of the star 51 Pegasi, the first star discovered to have a planet. The star 51 Peg is similar to our own sun. The observed velocity (in meters per second) is plotted vs. the time (in days) when the observation was made. The velocity of the star varies with time because the star and planet orbit around their common center of mass with a constant period.

Remember the Doppler shift? The star alternately moves toward and away from the Earth as it is tugged by the planet orbiting around it. Use the star’s observed velocity variations to estimate the approximate period of the planet’s orbit (the planet’s year).

1. What is the approximate period of the planet’s orbit in days? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. What is the maximum velocity with which 51 Peg moves away from the Earth? \_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. What is the minimum velocity with which the star moves toward the Earth? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. Sketch in a curve of the period you have identified with an amplitude that oscillates between the maximum and minimum velocities. You will need to fill in where the curve should go during times when no observations were taken (for example, between days 6 and 11, when the weather was cloudy*). Remember, the curve you sketch should have a period that does not change.*

5. Remember Kepler’s Laws? (P2=a3 for period “P” in years and semi-major axis “a” in AU) Estimate the semi-major axis of the planet. Assume that 51 Peg itself has a mass similar to the Sun’s. (Divide the period in days by 365 to convert it to the period in years.)

Period in years: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Semi-major Axis in AU \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

6. How does this compare to the distance from the Earth to the Sun (1 AU)?

**The Mass of 51 Peg’s Planet**: The following graph relates the mass of the planet to the orbital period, which can be estimated from the amplitude of the star’s variation in radial velocity. The masses of extra-solar planets are usually measured in units of the mass of Jupiter (e.g. 5 times the mass of Jupiter or 0.25 times the mass of Jupiter). This assumes that we are observing the planet in the plane of its orbit, and gives only an estimate of the minimum mass. The true mass could be greater.

1. Use the graph and the orbital period you measured to estimate the mass of 51 Peg’s planet.

Minimum mass of 51 Peg’s planet: \_\_\_\_\_\_\_\_\_

Summarize your findings in the table below:

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Orbital Period** | **Semi-Major Axis** | **Mass in MJup** |
| **Jupiter** | 11 years | 5 AU | 1 MJup |
| **51 Peg’s Planet** |  |  |  |

How does the mass of 51 Peg’s planet compare to Jupiter?

Given that 51 Peg is a star similar to our sun, what differences might you expect between 51 Peg’s planet and Jupiter based on your calculations?