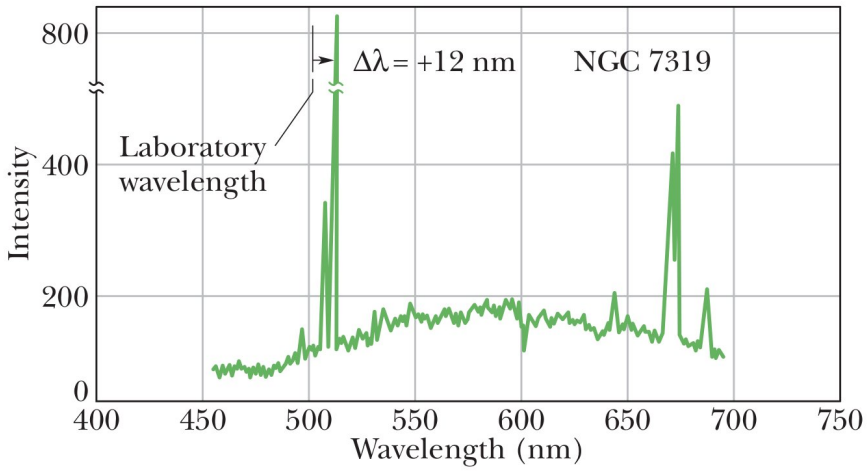
Extrasolar Planets

1. A spaceship, moving away from Earth at a speed of $v_a = 0.9c$, reports back by transmitting at a frequency (measured in the spaceship frame) of $f = 100\ MHz$. To what frequency must Earth receivers be tuned to receive the report?

2. The figure below is a graph of intensity versus wavelength for light reaching Earth from galaxy NGC 7319, which is about $3 \times 10^8 \ell y$ away. The most intense light is emitted by the oxygen in NGC 7319. In a laboratory that emission is at wavelength $\lambda = 513\ nm$, but in the light from NGC 7319 it has been shifted to 525 nm due to the Doppler effect (all the emissions from NGC 7319 have been shifted). (a) What is the radial speed of NGC 7319 relative to Earth? (b) Is the relative motion toward or away from our planet?



3. Consider a planet orbiting a star where the mass of the planet m_p is much less than the mass of the star M_s so $m_p \ll M_s$. What is the Lagrangian for the system? If the planet follows a circular orbit, then show

$$r = \left[\frac{GT^2 M_s}{4\pi^2}\right]^{1/3}$$

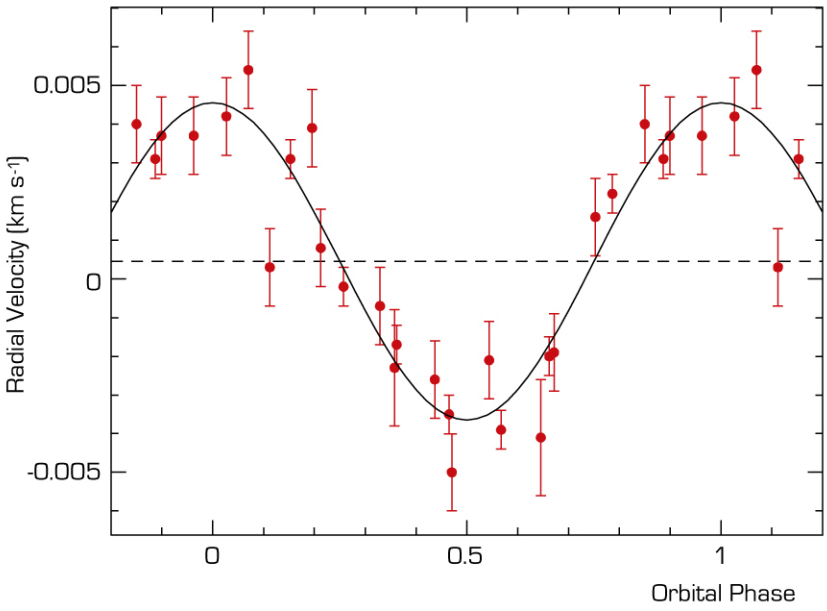
where T is the period of the planet's orbit and r is the distance from the star to the planet.

4. For a planet orbiting a much heavier star, show the distance from the planet to the center of mass is

$$r_p = \frac{M_s}{M_s - m_p} r$$

where r is the distance from the planet to the star, M_s is the star's mass, and m_p is the planetary mass.

5. In August 2004, observations of the star μ Arae revealed an oscillatory structure with a period $T = 9.5$ *days* shown in the figure. From its spectral type the mass of μ Arae is 1.10 solar masses. What is the minimum mass of this planet and its distance from μ Arae? How does this mass compare with planets in our solar system?



"Velocity Curve" of mu Arae

ESO PR Photo 25d/04 (25 August 2004)