Level 2 Stars, Workshop 2

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Binary stars

a) Assuming circular orbits, demonstrate that Keplers third law is the relation between the angular frequency and the mutual gravitational attraction of two stars in a binary system.

[Recall that Keplers third law is $P^2 = \dfrac{4\pi^2 a^3}{G(m_1 + m_2)}$, where P is the orbital period, a is the combination of the semi-major axes for the orbits of the two stars, and m_1 and m_2 are the individual masses of the two stars]

b) Given that the Earth orbits the Sun in one year at a distance of 1 AU, calculate the orbital period of the system if the Earth was replaced with a solar mass star?

c) How will the inclination angle (to your line of sight) of a visual binary system affect the mass measured using Keplers third law? How will the mass ratio of the two stars be affected by the inclination angle?

d) An analysis of the spectrum (the spectrum is shown on the next page) of an eclipsing, double line, spectroscopic binary with a period of 8.6 years shows that the maximum Doppler shift of the Hydrogen Balmer Hα (6562.8Å) line is $\Delta\lambda_s = 0.72$ Å for the smaller star and only $\Delta\lambda_l = 0.068$ Å for the companion. From the sinusoidal shapes of the radial velocity curves, it is also apparent that the orbits are nearly circular.

i. Calculate the mass ratio of the two stars.
ii. Assuming that the inclination of the system is 90^o, calculate the velocity in km/s and radius of the orbits in AU of the two stars.
iii. Calculate the sum of the masses of the two stars in units of solar masses.
iv. Calculate the masses of the two individual stars in units of solar masses.

e) From the light curve (see the figure below) of the eclipsing spectroscopic binary in part (d), it is found that t_b-t_a = 11.7 hours, and t_d-t_b = 164 days. Calculate the radii of the two stars in units of solar radii.

[1 AU = 1.50 x 10^{11} m, $M_\odot$ = 1.99 x 10^{30} kg, $R_\odot$ = 6.96 x 10^8 m, $L_\odot$ = 3.85 x 10^{26} W, 1 eV=1.60 x 10^{-19} J]

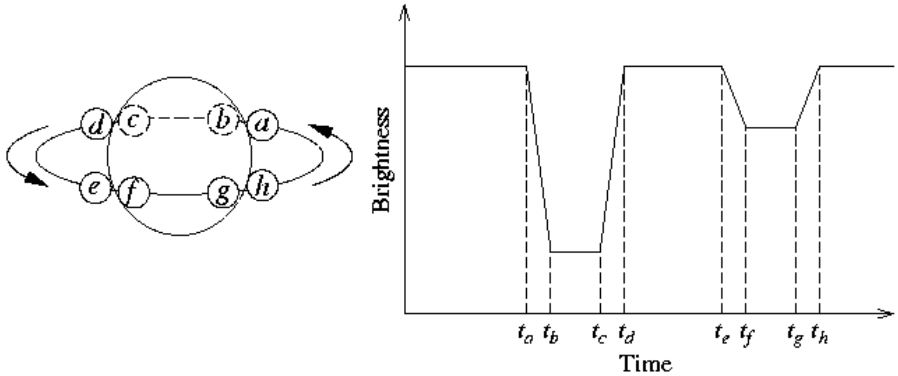

Fig: Eclipsing binary light curve