Binary Systems

Classification:

apparent binary = "optical double" = NOT a physical binary system

visual binary = the projections of both components' orbits can be traced out on the sky

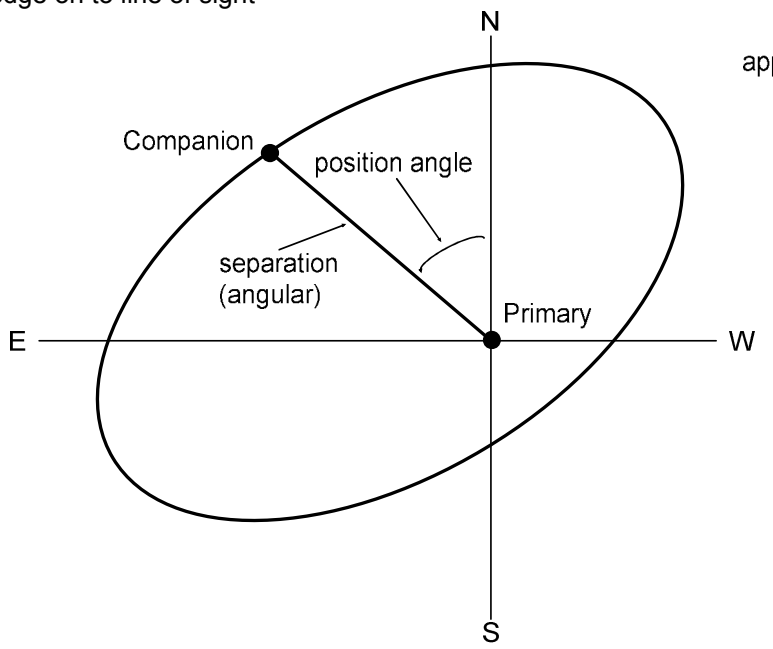
spectroscopic binary = one or both components' spectra can be used to determine radial velocity curves for the components

eclipsing binary = components periodically eclipse one another

eclipsing-spectroscopic binary = both light curve and velocity curve data measurable

Visual binary systems

Observational definitions: apparent relative orbit = projection of true orbit onto plane of sky, inclination = angle of true orbital plane to plane of sky (i = 0 deg: planes conincide; i = 90 deg: orbital plane edge on to line of sight



apparent relative orbit

NOTE: focus point of apparent orbit and Primary do not coincide, use displacement to determine: inclination (i), eccentricity (e), and the true semimajor axis angular size (a'')

Visual binary determination of the mass:

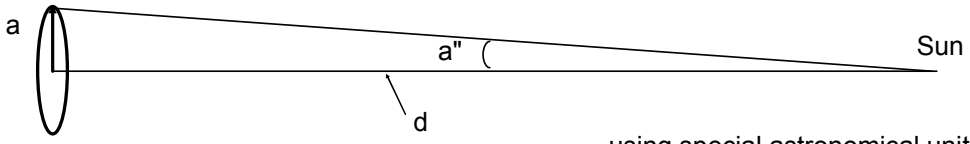
$$\frac{P^2}{a^3} = \frac{4\pi^2}{G(m_1+m_2)}$$

NOTE: m_1 = primary, m_2 = companion

P, a from true orbit and a must be in distance units, not observed angular units

true orbit

$$a = a'' d$$

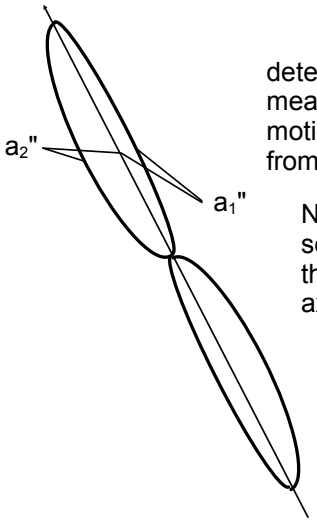


using special astronomical units: a (AU), P (years), m_1 & m_2 in solar mass units ($M_\odot$)

determine the total mass of the system:

the equation becomes:

$$m_1+m_2 = \frac{4\pi^2 a^3}{GP^2} \qquad m_1+m_2 = \frac{a^3}{P^2}$$



determine the true angular semimajor axes of the two components by measuring the oscillatory motion of the two components as their proper motion carries them across the sky, the true angular axes are determined from the known inclination of the orbital plane to the plane of the sky

Note that the ratio of the true angular semimajor axes will be the same as the ratio of the true linear semimajor axis

$$\frac{a_2}{a_1} = \frac{a_2''}{a_1''}$$

and from center of mass considerations:

$$m_1 a_1 = m_2 a_2 \rightarrow \frac{m_1}{m_2} = \frac{a_2}{a_1} = \frac{a_2''}{a_1''}$$

Now from the known sum of the masses and the know ratio of the masses, solve 2 equations, 2 unknowns to determine the individual masses of the components: m_1 & m_2

Mass-Luminosity Relation: developed primarily from visual binary data (Luminosity from known distance and measured apparent brightness, masses from orbit analysis of visual binaries)

$L/L_\odot = (M/M_\odot)^\alpha$ $M < 0.43M_\odot$ $\alpha = 2.3$ $M > 0.43M_\odot$ $\alpha = 4$