

Binary Stars

- Optical double stars : Two stars lying close to the same line of sight. Not gravitationally bound. At different distances.

Physical binary stars : Two stars in orbital motion around a common center of mass.

- Designation :

Brighter star in the pair : A (Sirius A; A1V)

Fainter star in the pair : B (Sirius B; white dwarf)

More massive star in the pair : primary star

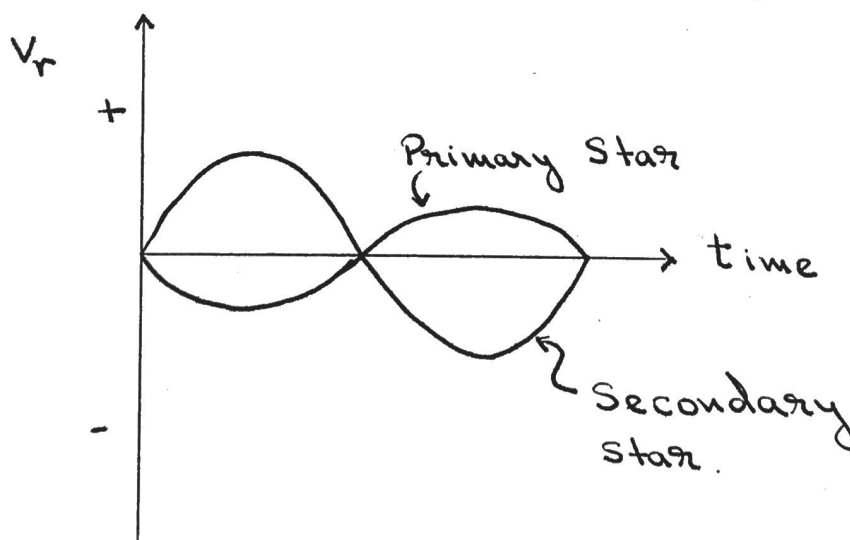
Less massive star in the pair : secondary star

- Types of binaries : Binaries are classified according to the observational technique used to detect them.

1) Visual binary : Both members can be resolved by a telescope. Usually they are nearby or the members are far apart. They have long periods.

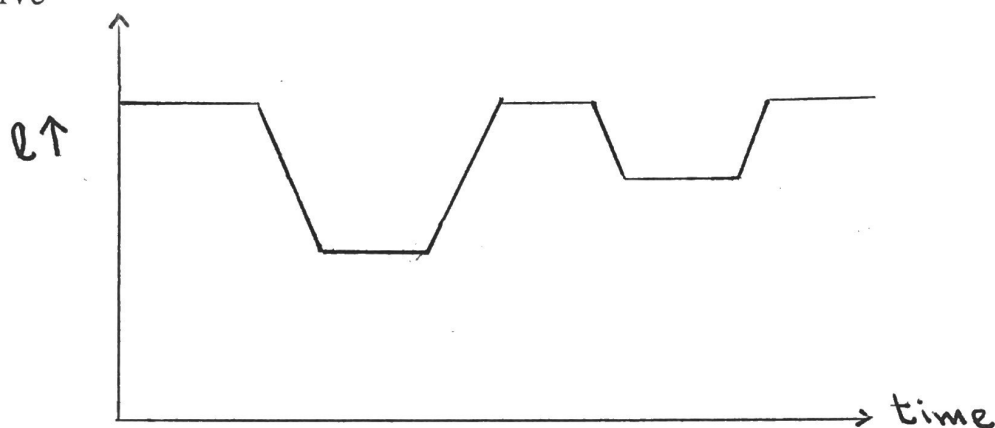
2) Spectroscopic binary : Cannot be resolved into two stars. But the spectrum reveals two sets of spectral lines. The lines shift periodically indicating a mutual orbit.

Radial Velocity Curve



3) Eclipsing binary : Orbital plane along (parallel) to the line of sight. The stars undergo mutual eclipses.

Light Curve



Most eclipsing binaries are also spectroscopic binaries.

4) Astrometric binary : Only one component is seen. This star describes an oscillating path w.r.t. background stars. The periodic changes in the position of the visible component indicate an unseen companion.

5) Spectrum binary : Unresolved star. Spectrum reveals lines due to two distinct spectral classes. No detectable Doppler motion.

- Determination of mass :

- Obtain period P in years.
- Obtain distance and angular separation.

Convert to linear separation a in A.U.

- Calculate sum of the masses from Kepler's 3rd law

$$(m_1 + m_2) P^2 = a^3$$

- Obtain center of mass from astrometry.

Calculate individual masses from

$$m_1 \times d_1 = m_2 \times d_2$$

- Determination of diameter :

- Obtain relative velocity v from radial velocity curve.
- Obtain times t_1 and t_2 from light curve
- Diameter of smaller star = $v \times t_1$
- Diameter of larger star = $v \times (t_1 + t_2)$

- What percentage of stars are binaries or multiple systems?

Observations biased by selection effects. We choose spectroscopic binaries that have small separation and high Doppler velocity. Visual binaries with wide separation are usually selected. As a conservative estimate there are more than 50% of stars in binary or multiple systems.

- Surrounding each star in a binary system is a gravitational equipotential surface - Roche Lobe or Lagrangian surface. The inner Lagrangian point is a point where the gravitational force due to the two stars are equal and opposite. Mass transfer between the stars takes place through this point.

- An alternative way of classifying binary stars

- 1) Neither star fills its Roche Lobe.
- 2) One of the stars fills its Roche Lobe.
- 3) Both stars fill their Roche Lobe.

