

Astronomy Exercise 6

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1. Binary stars

a) Briefly describe the four methods used to identify a binary star system

Visual Observation: Observing stars through telescopes to identify any apparent motion or orbiting behavior over time.

Astrometric Method: Precision measurement of star positions to detect periodic shifts indicative of gravitational influence from an unseen companion.

Radial Velocity Method: Analyzing star spectra for periodic Doppler shifts, uncovering changes in radial velocity caused by the gravitational pull of an unseen companion.

Eclipsing Binary Method: Monitoring changes in star brightness over time, identifying regular variations as one star eclipses the other in a binary system.

b) Two binary components are in circular orbits around their center of mass, how does the mass ratio of these components relate to the ratio of their orbital velocities?

In a binary system with components orbiting each other in circular orbits around their center of mass, the mass ratio of the components is inversely related to the ratio of their orbital velocities.

$$\text{Mass Ratio} = \frac{v_2}{v_1} = \frac{m_1}{m_2}$$

where, v_1 and v_2 are the orbital velocities of the first and second component and m_1 and m_2 denote the masses of the first and second component.

The equation suggests that in a binary system with circular orbits, the larger mass will possess a comparatively slower orbital velocity, while the smaller mass will demonstrate a higher orbital velocity. This equilibrium is crucial for maintaining a nearly stationary center of mass, enabling both components to orbit around it in a synchronized manner.

c) The star Alpha Centauri is a visual binary system with a measured period of 79.9 years. Its observed parallax is $0.737''$. Assuming that the orbital plane is in the plane of the sky and that the orbits are circular, the angular separation of the two stars was measured to be $17.5''$. The distance ratio to the center of mass is given by $\frac{a_A}{a_B} = 0.83$. Estimate the mass of the two stars and express its value in solar masses.