Indian Institute of Science Education and Research, Mohali

Astronomy and Astrophysics (IDC201)

(January – April, 2021)

Problem Set 3

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1. Use the data for the Pleiades, Hyades and 47 Tuc star clusters to plot the color magnitude diagram. Use the offset in the apparent magnitude to calculate the relative distances.

2. See the observed light curves for two Cepheid variables shown in Figures 1 and 2. The period luminosity relation is:

$$M_V = -2.43\,(\log P - 1) - 4.05$$

Here, M_V is the absolute magnitude and P is the time period in days. Estimate the distance to the two Cepheid variables.

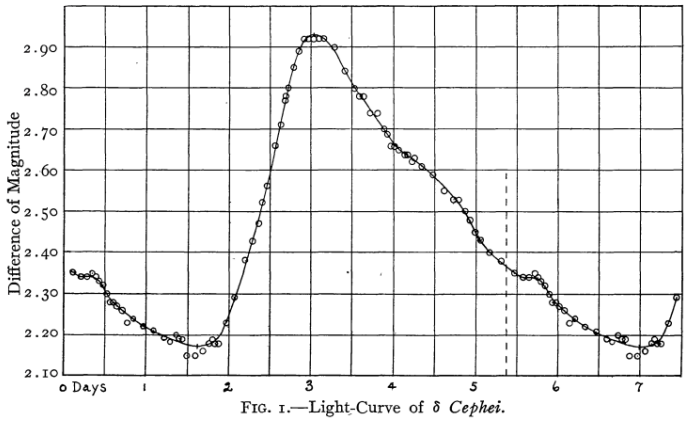

FIG. 1.—Light-Curve of δ *Cephei.*

Figure 1: Observed light curve for the star δ Cephei.

3. Cygnus X-1 is a single-line spectroscopic binary with an orbital period of 5.6 days and radial velocity amplitude K_2 = 76 km s^{-1}. Using the Kepler's laws derive its mass function in units of solar masses? If M_2 is unknown is there a solution allowed in which $M_1 < 2.0$ solar masses.

4. Repeat the above for XTE J1118+480 with period of 0.17d, and K2 =709 km/s.

5. Let us assume that you have built a nice camera with angular resolution of 0.1 arcsec (it means that a star will appear to have a disk of 0.1 arcsec diameter) and that you can measure the position of a star accurate to 0.01 arcsec, and you set out to measure to observe the centre of the Milky Way which is at a distance of 8 kpc (1kpc = 1000pc, 1 pc = 3.1×10^{18} cm).

   (a) At that distance what would a linear separation of 0.1 arcsec between stars correspond to ?

   (b) If a star is in a Keplerian orbit around a million solar mass black hole with a orbital separation in (a) above, what would be its velocity in km/s?

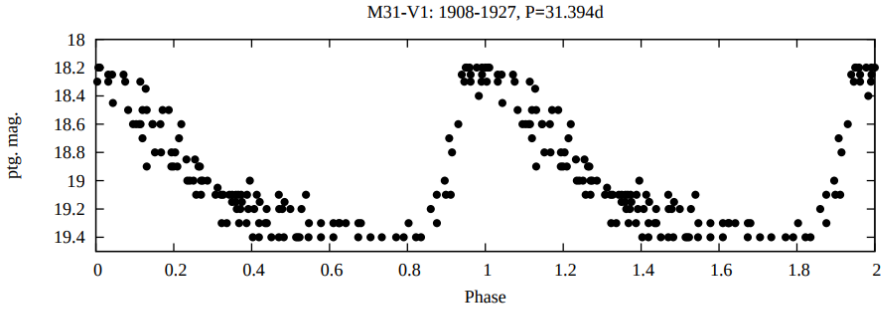

Fig. 5.— Data shown in Figure 4 folded with a period of 31.394 days. We used $JD_0 = 2422694.3$ to phase the data.

Figure 2: Observed light curve for the cepheid variable star V1 in Andromeda (M31) galaxy (ignore the other caption inside the figure)

(c) If the star is moving along a straight line at the above velocity how much linear distance would it move in 1 year (in kms)? If that movement is entirely in the plane of the sky, how much angular distance would it move in 1 year?

(d) Given the above simplified calculations is your instrument useful for determining the existence or non-existence of a black hole at the centre of the Milky Way ?