

Galactic Astronomy, Spring 2017

PROBLEM SET II

Deadline: 5PM OF WEDNESDAY, APRIL 12, 2017

1. **Period-luminosity (PL) relation (10%).** Given that the luminosity L of a massive H-burning star varies with mass roughly as $L \propto \mathcal{M}^3$, show that, at fixed effective temperature, the fundamental pulsation period of such stars scales as $P \propto L^{7/12}$.

2. **Distance to Virgo cluster (10%).** Several remote classical Cepheids were discovered in 1994 by the Hubble Space Telescope (HST) in the galaxy denoted M100, which is a member of the Virgo cluster, a rich cluster of galaxies. Fig. 1 shows the period-luminosity relation for these Cepheids. Use the two Cepheids nearest the best-fit line (solid line) to estimate the distance to M100. The mean visual extinction is $A_V = 0.15 \pm 0.17$ mag for the M100 Cepheids.

You are encouraged to read the original work by Freedman et al. (1994, *Nature*, 371, 757) for more information on the discovery and importance of these remote pulsating stars.

3. **Evolution of stellar population (15%).** Answer the following questions using the color-magnitude diagram for the globular cluster M3 (Fig. 2).

(a) Estimate the turnoff point age for M3. (5%)

(b) Estimate the age of M3 using the ΔV method. (5%)

(c) The color of a horizontal branch (HB) star can depend quite sensitively on the amount of mass $\Delta\mathcal{M}$ it has lost. Given that the typical dispersion in mass lost is only $\sim 0.02\mathcal{M}_\odot$, estimate the dependence, $\partial(B - V)/\partial\Delta\mathcal{M}$ (mag \mathcal{M}_\odot^{-1}), for M3. (5%)

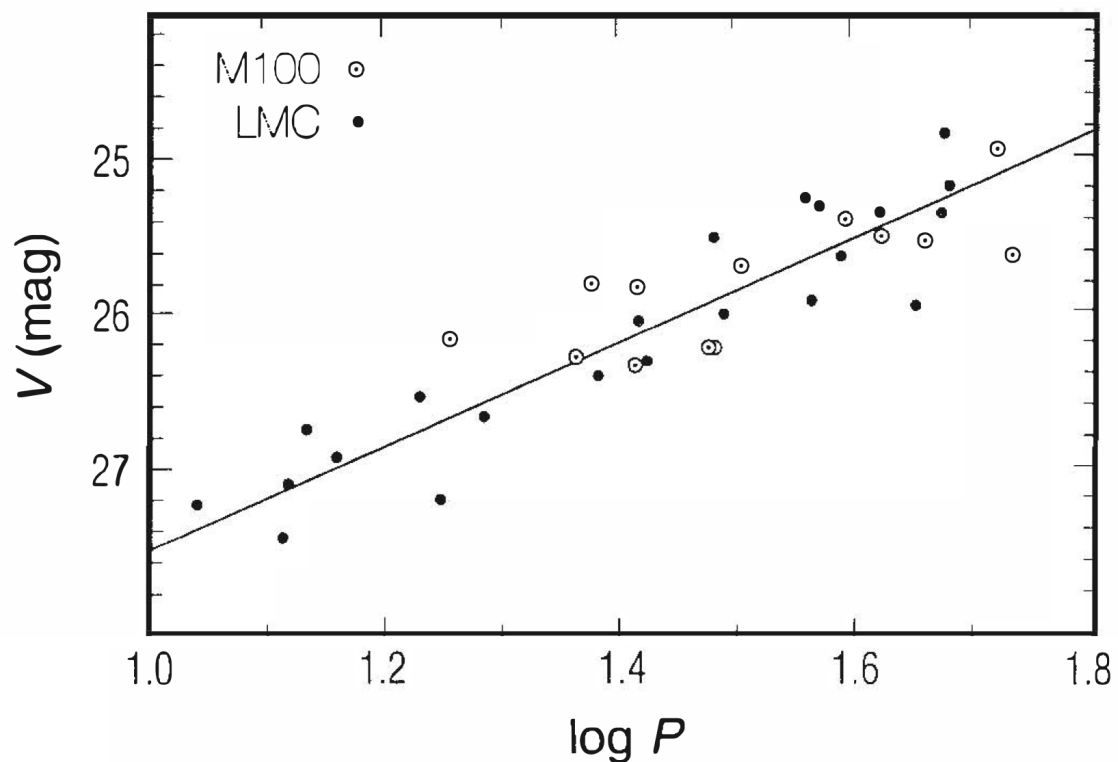


Figure 1: Composite period-luminosity relations for Cepheids in M100 (*white circles*) and Cepheids in the LMC (*black circles*). The average visual magnitudes of the LMC Cepheids have been shifted by the same amount to match those of the M100 Cepheids. The required increase in the V band for a best fit is then used to find the relative distances to the LMC and M100. (Adapted from Freedman et al. 1994, *Nature*, 371, 757)

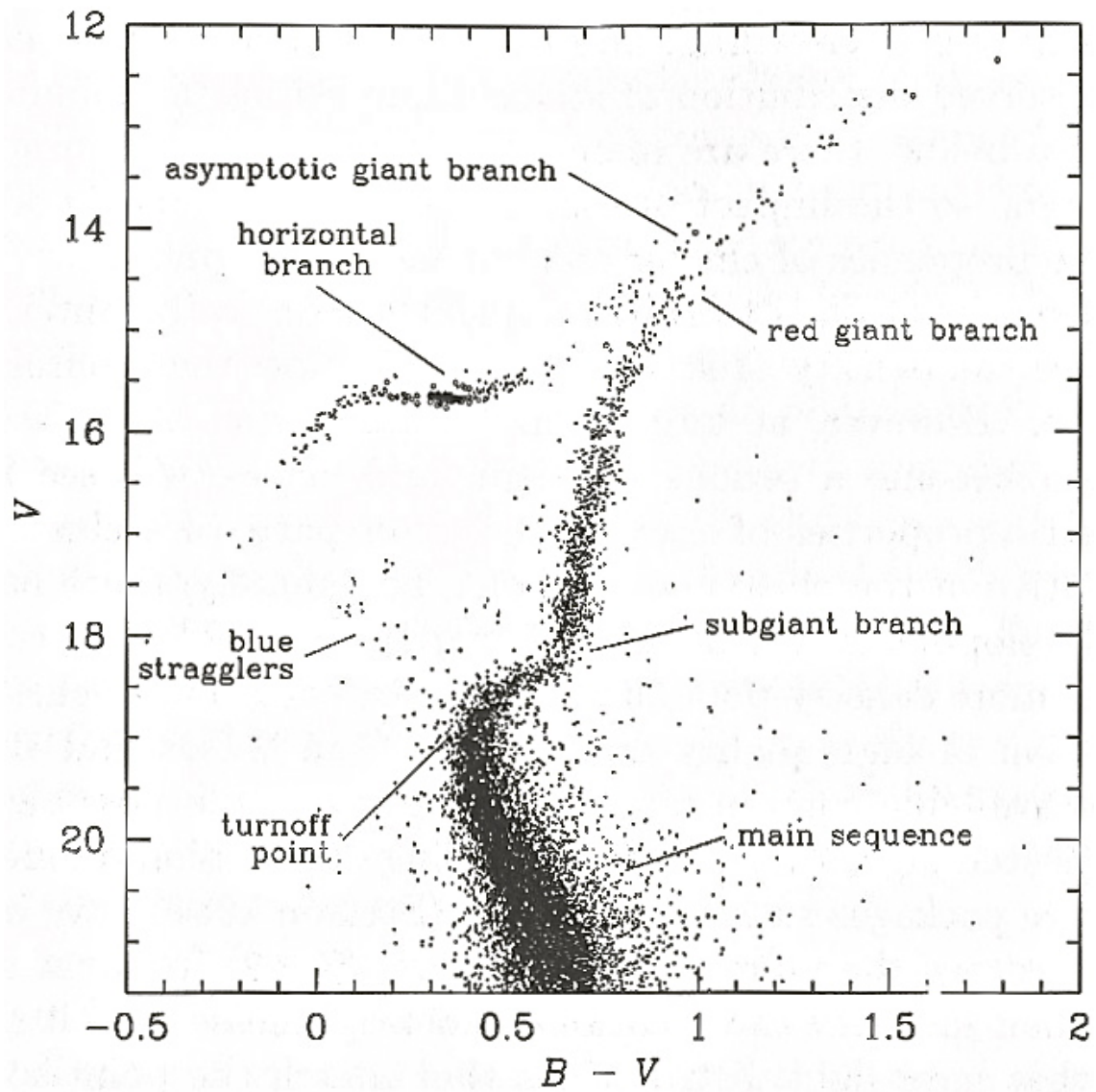


Figure 2: The color-magnitude diagram for the globular cluster M3 with annotation of principal sequences. (Fig. 6.2 in Binney & Merrield)