Exam Stellar Structure and Evolution

1 February 2017, 09:00–12:00

Name & Student Number:

This part of the exam is written with oral clarification if you choose so and counts for 10 points. The MESA lab work + its obliged oral exam also counts for 10 points. A maximum of 2 bonus points could be earned by the timely writing and submission of an Executive Summary of the seminar by Prof. S. Owocki as communicated in the lectures and through Toledo.

1. Consider the colour-magnitude diagrams of three stellar clusters on the following page. These clusters have the following properties ($Z_\odot$=0.0134):

Cluster	Mass at turn-off point ($M_\odot$)	$Z(Z_\odot)$
Pleiades	4.8	1.0
M3	0.8	0.45
Hyades	2.3	1.2

- Ignore the occurence of binarity in the three clusters. Estimate the cluster ages. In order to do so, you can make use of the mass-luminosity relation. In the lectures, this relation was discussed for ZAMS stars of solar metallicity. A more general relationship valid for core-hydrogen burning stars of various metallicity is as follows:

$$\begin{cases} L \sim M^{7/2} & \text{for } Z \geq Z_\odot,\ M \geq M_\odot \\ L \sim M^5\ Z^{-7/6} & \text{for } Z < Z_\odot,\ M < M_\odot \end{cases}$$

  Which cluster is the oldest? Which one is the youngest?

- Fill all cells in the table on the next page and indicate the stellar types in the colour-magnitude diagrams, as requested.

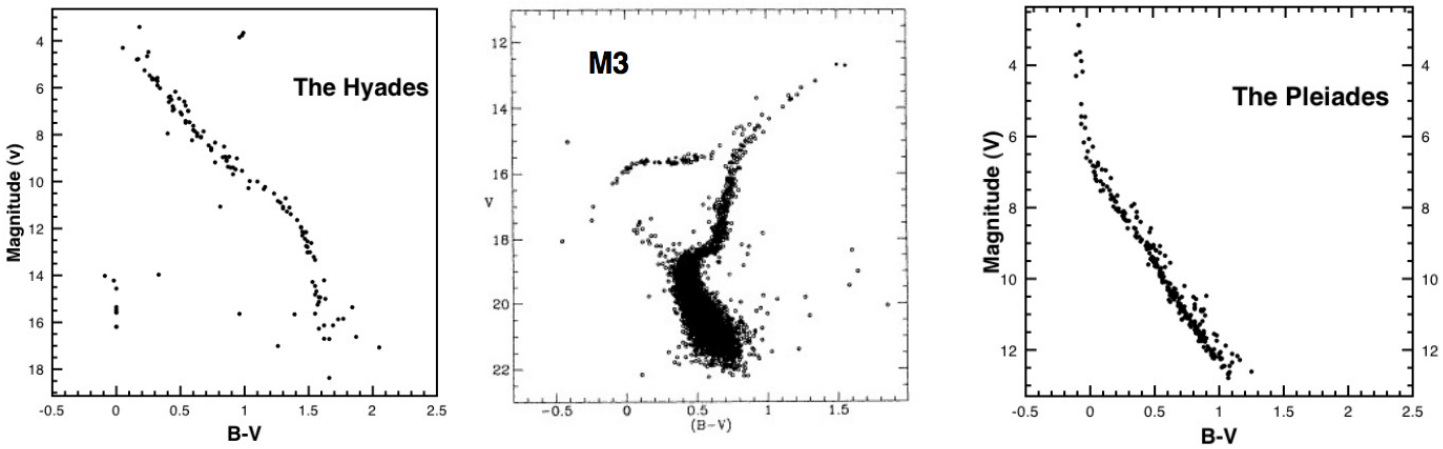
- Consider stars of Population II with $Z = 10^{-4}$ belonging to a single generation born only 10^8 years after the Big Bang, i.e. assume that their age is 13.8×10^9 years. Explain in words what the maximal possible range in birth mass of these stars is and why. Compute for which mass range of this generation the stars are still in the core-hydrogen burning phase. Can any of these stars occur in the three clusters? Why (not)?

(6 points)

2. Explain the following concepts (maximally 1 A4 page for all four) and indicate for which range in stellar birth mass they are relevant:

   - ON star
   - Hot Bottom Burning
   - the stability criterion of Ledoux
   - Humphreys-Davidson Limit

   (4 points)



Cluster	ZAMS star	white dwarf	AGB star	HB star	red giant
Pleiades					
M3					
Hyades					

Fill all cells in this table. Fill the cells with "Y" if the type of star occurs in the observed colour-magnitude diagram of the cluster and "N" if it does not occur in the figure. If "Y", indicate on the colour-magnitude diagram of the cluster where such stars are situated.