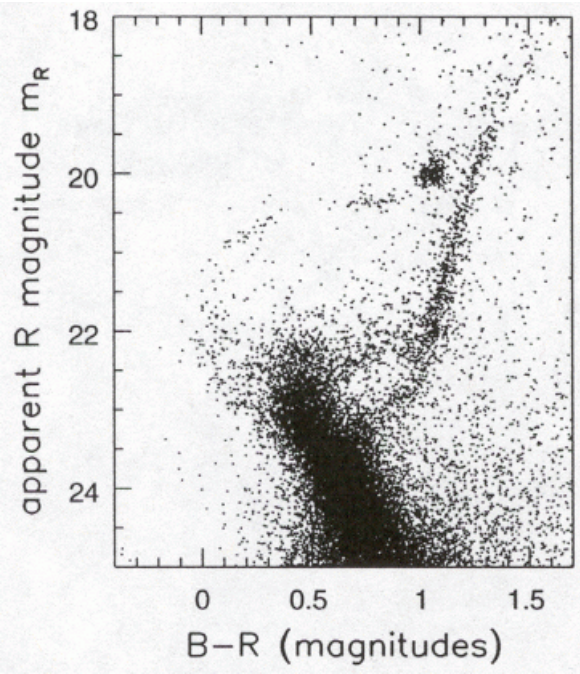
THE HERTZSPRUNG-RUSSELL DIAGRAM: SELF TEST

These are questions from old exam papers. If you can't do them, read the document on the Hertzsprung-Russell diagram available from the course web page.

1. The diagram shows the Hertzsprung-Russell diagram of a dwarf galaxy, Carina, in terms of the apparent red magnitude R and the colour index $B - R$.

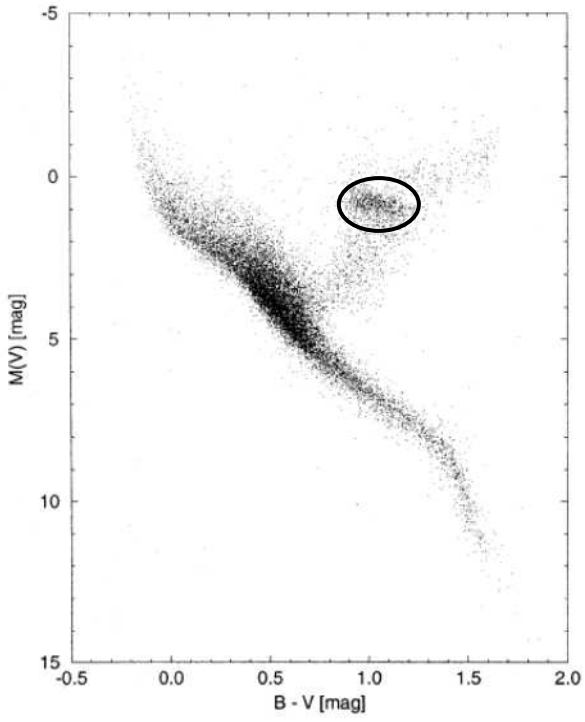


(i) Look carefully at this diagram. Would you say that, on the whole, the stars of Carina were young or old? Explain your reasoning. [1]

(ii) Based on this diagram, I would claim that Carina has had two major periods of star formation, and that it contains two populations of stars that differ in their heavy element content. Carefully explain which features of the diagram support my claims, and why. [4]

[2011/12, Q C1(b).]

2. The diagram on the right is the Hertzsprung-Russell diagram for nearby stars, as measured by the Hipparcos satellite.
   a. Explain carefully how we know from looking at this diagram that the stars near the Sun are not all the same age. [4]
   b. The stars circled on the diagram are horizontal-branch stars. What do these stars tell us about the heavy-element content of stars near the Sun? Briefly explain your reasoning. [2]
   c. Do the stars shown in the diagram comprise a fair and representative sample of stars in the neighbourhood of the Sun? Justify your answer. [2]



[2010/11, Q C1 (b)-(d)]

3. The diagram in question 2 shows the Hertzsprung-Russell diagram for nearby stars whose parallaxes were accurately measured by the Hipparcos satellite.
   a. The *colour index B – V* of the star measures, as the name suggests, the star's apparent colour. What physical property of the star determines its colour? [1]
   b. What features of this diagram show that the solar neighbourhood contains stars of different ages, including stars which are younger than the Sun? [2]
   c. Hipparcos had a relatively small telescope. What differences would you expect to see in this diagram if Hipparcos had been equipped with a larger telescope? [2]
   d. The vast majority of the stars in the diagram are on the main sequence. Explain what defines a main sequence star, in terms of its energy generation mechanism, and why we should expect most stars to be on the main sequence. [2]

   Note that the Sun's absolute magnitude is approximately 5.

   [2005 Q B2 and 2007 Q C1(a)]

4. The HR diagram of an old cluster is likely to include the following four branches (working from the top down):

   A. the red giant branch;

   B. the horizontal branch;

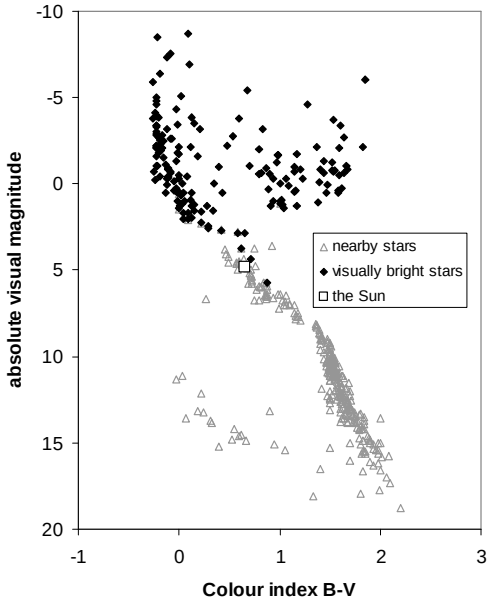
   C. the main sequence;

   D. the white dwarfs.

   a. Put these branches in the order in which they would be visited during the evolution of a Sun-like star. [1]
   b. For each branch, explain what (if anything) is being fused to generate energy, and where. [4]
   c. Use the above information to describe the evolution of a Sun-like star. [4]

   [2006 Q C1(a)]

5. The picture below is the Hertzsprung-Russell diagram for the brightest stars in the night sky (black diamonds) and the stars closer than 30 light years away (grey triangles). The Sun is shown by the large square.



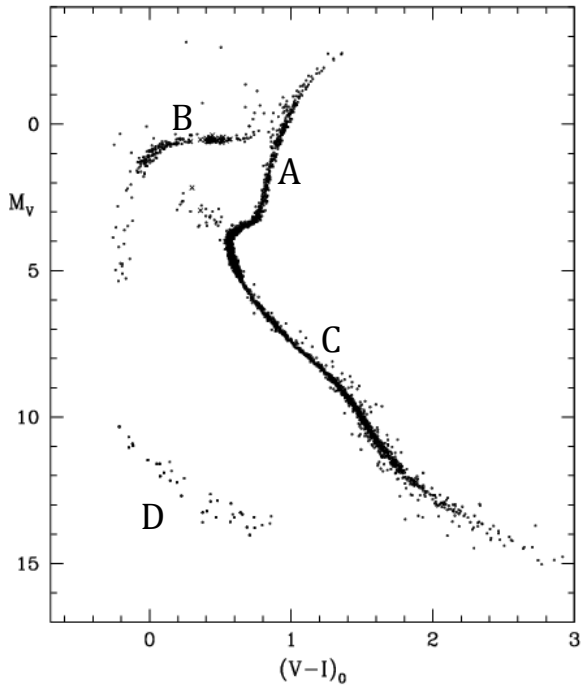
   a. Explain what this picture tells us about the masses of (i) the stars we see in the night sky and (ii) the stars which are close to us in space. [1]
   b. Explain how we know that the nearby stars found towards the bottom left of the diagram are much smaller in size than the Sun. [1½]
   c. Explain how we know *from observational data* that the bright stars in the night sky include some which are much younger than the Sun is. [1½]
   d. Which of these two sets of stars would you say is likely to be *typical* of the stars in the disc of the Milky Way Galaxy? Justify your answer. [1]

   [2008 Q B2]

6. Make careful drawings of the Hertzsprung-Russell diagrams of (i) a young star cluster and (ii) an old star cluster low in heavy elements. Label the branches of the HR diagram shown in your drawings. [5]
   a. With reference to the mass-luminosity relation obtained from binary stars, explain what feature of your diagrams defines the clusters as young and old, respectively, and briefly comment on how the other features of the diagrams shed light on the likely progress of stellar evolution. [2]
   b. What feature of your "old star cluster" diagram indicates that the cluster is low in heavy elements? [1]

   [2013, Q C1(c)]

7. The picture below shows a detailed HR diagram of a globular cluster.



   a. Explain which features of the HR diagram show that this cluster is (i) old and (ii) low in heavy elements. [2]
   b. Name the branches of the HR diagram labelled A, B, C and D in the figure. In each case, state which element, if any, is being fused to generate energy, and where in the star this fusion is occurring. [6]
   c. Describe the life cycle of a typical solar-mass star from its formation to its eventual demise. Relate your account to the features of the HR diagram shown. [6]
   d. Would you expect to find planets orbiting the stars in this cluster? Briefly justify your answer. [1]

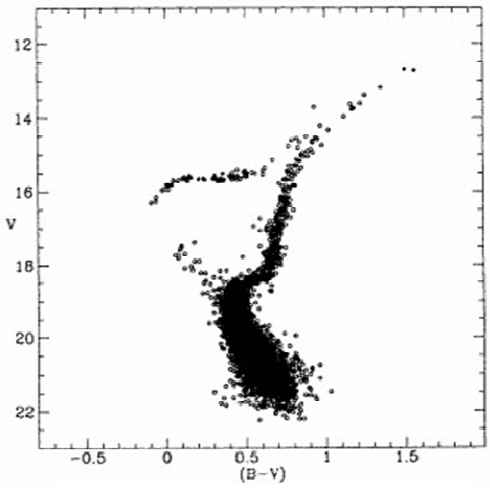
   [2007 Resit Q C1]

TYPICAL SECTION A QUESTIONS

A1 (Tick or circle *all* answers that apply.) Stars which are members of the same star cluster

(i) are all the same age;
(ii) all have the same mass;
(iii) are all on the same branch of the Hertzsprung-Russell diagram;
(iv) all have the same initial chemical composition;
(v) are all about the same distance from us.

The picture shows the Hertzsprung-Russell diagram of a star cluster: V represents apparent visual magnitude, and B – V is a colour index. Use this diagram to answer questions A2–A7.



colour index B – V

A2 Circle on the picture the *hottest star* (label it H) and the *coolest star* (label it C).

A3 Circle the *largest* star (label it L).

A4 Circle some stars which are *not fusing hydrogen to helium* (label them A4).

A5 The stars in this cluster are:

(a) young;
(b) old;
(c) of several different ages;
(d) none of the above – it is impossible to tell just from the HR diagram.

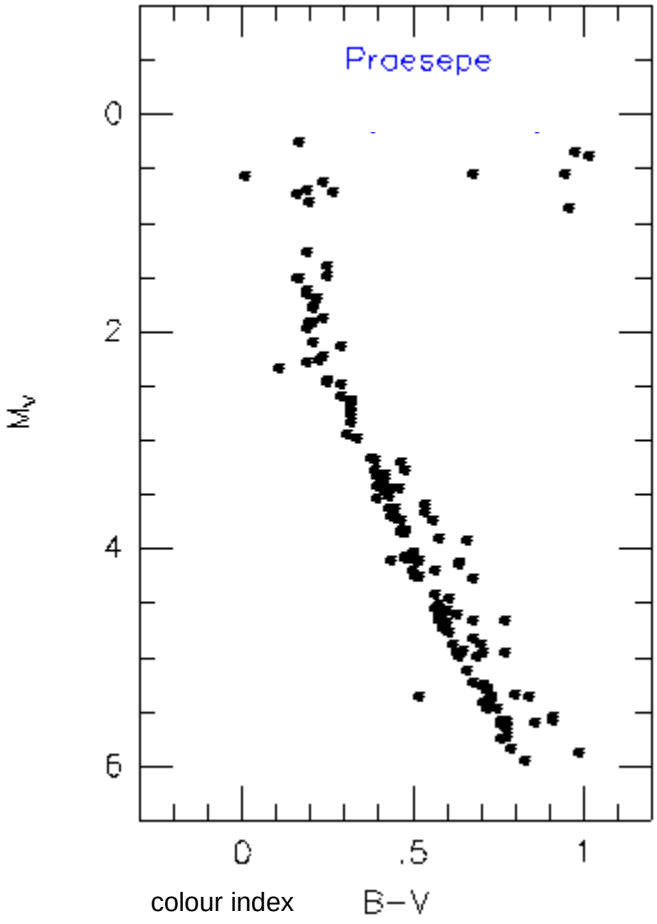
A6 You would expect to find a cluster like this:

(a) far from the plane of the disc of the Milky Way;
(b) close to the plane of the disc of the Milky Way;
(c) anywhere at all in the Milky Way;
(d) not in the Milky Way at all, but only in an elliptical galaxy.

A7 This cluster is

(a) young and high in heavy elements;
(b) young and low in heavy elements;
(c) old and high in heavy elements;
(d) old and low in heavy elements.

The picture below shows the Hertzsprung-Russell diagram of a stellar cluster. Use this diagram to answer questions A8-A10.



A8 Mark on the diagram the *hottest* star (label it H) and the *coolest* star (label it C).

A9 Circle on the diagram the *most massive stars.*

A10 This cluster is:

(a) young;

(b) old;

(c) composed of stars of widely different ages;

(d) of unknown age – the HR diagram does not contain enough information to let us estimate the age of the cluster.