

Regents Earth Science

47 Tucanae

INTRODUCTION:

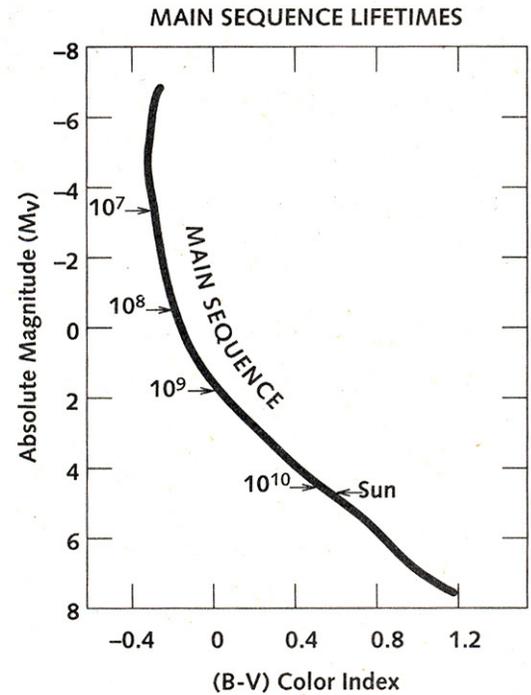
The Temperature and Luminosity of Stars diagram on page 15 of the ESRT is a graph that shows stars' temperatures versus their luminosities. Because a star's color is directly related to its temperature, and because its luminosity is directly related to its absolute magnitude (brightness), a color-magnitude diagram shows very similar information and can be plotted directly from observations made with telescopes.

A *globular star cluster* is a group of stars that formed out of the same gaseous material at the same time billions of years ago. 47 Tucanae is one such globular cluster. Because all the stars in 47 Tucanae are thought to be the same distance away and the same age, the cluster's properties can be determined simply by studying a color-magnitude diagram. For example, the color magnitude diagram of a cluster can then be compared to models of stellar evolution such as the one shown in the figure to the right to help determine the age of the cluster's stars.

About how long will a star with an absolute magnitude of 2 and a color index of 0 "live"?

PROCEDURE:

1. The third page of this activity shows a color-magnitude diagram that already has 60 of the nearest and brightest stars plotted. The color index (B- V) indicates the difference in the color of a given star. A more positive value indicates a red star and a more negative value indicates a blue star.



Now use the graph and the temperature and Luminosity of Stars diagram on page 15 of the ESRT to ANSWER Analysis and Conclusion Questions 1-6.

2. Now you will add stars that have been observed in 47 Tucanae to the color-magnitude diagram. This star cluster contains tens of thousands of stars, so plotting the entire cluster is not feasible. Take a straightedge (the spine of your ESRT) and a pencil and draw a box to outline the region on the color-magnitude diagram that extends from +0.36 to +0.90 in (B-V) color index, and from +5.3 to +3.3 in absolute magnitude. Label the inside of this box "Most 47 Tucanae Stars."
3. Use the table on the next page to plot that selection of stars from 47 Tucanae on the color magnitude diagram. Note that the stars have been broken into three separate lists of stars.
4. The three lists of stars you have plotted in Step 3 represent three different types of stars. You have already labeled the region where one type of star would be found for 47 Tucanae. Now, draw a circle around each group of stars on your graph, and label them "Red Giants," "Faint Red Giants," and "Blue Stragglers."

ANSWER QUESTIONS 7 - 9

47 Tucanae Star Data Table					
Star List #1		Star List #2		Star List #3	
Absolute Magnitude (M_v)	Color Index (B-V)	Absolute Magnitude (M_v)	Color Index (B-V)	Absolute Magnitude (M_v)	Color Index (B-V)
+1.1	+0.87	-1.5	+1.30	+1.7	+0.06
+1.3	+0.96	-1.4	+1.85	+1.8	+0.31
+1.3	+0.78	-1.3	+1.38	+2.2	+0.28
+1.5	+0.86	-1.3	+1.70	+2.4	+0.43
+1.7	+0.82	-1.2	+1.18	+2.5	+0.34
+2.0	+0.86	-1.1	+1.13	+2.5	+0.47
+2.1	+0.76	-1.0	+1.05	+2.7	+0.38
+2.3	+0.70	-1.0	+1.26	+2.7	+0.13
+2.4	+0.83	-0.9	+1.16	+2.7	+0.41
+2.7	+0.82	-0.8	+1.08	+2.8	+0.33
+2.8	+0.75	-0.7	+1.12	+2.9	+0.41
+2.9	+0.69	-0.6	+1.32	+3.0	+0.45
+3.0	+0.84	-0.4	+1.08	+3.1	+0.11
+3.1	+0.73	-0.1	+1.09	+3.2	+0.41
+3.2	+0.77	+0.2	+1.05	+3.2	+0.47
+3.2	+0.58	+0.6	+1.01	+3.2	+0.38

Source: Guhathakurta, P. et al, *The Astronomical Journal*, 104, p. 1790

Analysis and Conclusions

1. A star located in the lower right portion of the color- magnitude diagram is cool and dim. What are the characteristics of a star in the upper left of the diagram?

What about the upper right of the diagram? _____

2. To which group do the majority of the stars in the color-magnitude diagram belong? _____

3. Are any of the 60 stars plotted on the color-magnitude diagram white dwarfs? _____ How can you tell?

4. Our sun has an absolute magnitude of +4.7 and a (B- V) color index of about 0.80. Plot the sun on the color magnitude map using a *. To what group of stars does the sun belong?

5. Betelgeuse is a very cool, red star. It has a (B- V) of + 1.86 and is 150 parsecs away. Yet, it is the star with the greatest absolute magnitude on the color-magnitude diagram. What does this indicate about the size of Betelgeuse?

Does its location on the diagram support your answer? _____ Why isn't Betelgeuse the brightest star in the night sky?

6. The other supergiant plotted on the color-magnitude diagram represents Antares. Which star is farther along in its evolution, the sun or Antares? _____ How can you tell?

7. The diagram on page 1 of this lab shows the amount of time a star can be expected to lie on the main sequence. After its main sequence lifetime expires, the star eventually begins to “burn” helium and becomes a red giant. About how long, in billions of years, will the sun remain on the main sequence? (Briefly explain your answer)

8. If you assume that all the red giants in 47 Tucanae have evolved from stars that had a (B-V) color less than +0.56 on the main sequence, about how old, in billions of years, is the star cluster 47 Tucanae? Explain your answer.

9. The blue stragglers of 47 Tucanae are stars which are so massive that they should have already evolved off of the main sequence. For some reason, they have not evolved farther. One possible explanation is that because stars lie so close together inside a globular cluster, a blue straggler may be the result of two stars having come together. Explain how combining two stars explains the presence of blue stragglers. Where on the color-magnitude diagram would these stars have “moved” to had they not combined into a blue straggler?

