The Hertzsprung-Russell Diagram and Stellar Evolution

Firstname Lastname

Date

1. Replace the red text at the top of this page with your name and the date.

2. As you enter your work, please make sure that your answers stay red (like this). This will make them easier to see, and thus it will be easier for us to grade them accurately. To convert black text to red, highlight it and then click on the “A” symbol in the menu bar above, to the right of the “**B**”, “*I*”, and “U” symbols. Select the red square to turn your highlighted text red.

3. Delete these 3 initial instructions from this template as soon as you have followed them.

The H-R Diagram and Stellar Properties Activity

1. In which corner of the diagram (upper right, upper left, lower right, or lower left) would stars with radii 1000 times larger than that of the Sun be plotted? Replace this text with your answer, leaving it in red.

In which corner would stars with radii 1000 times smaller than that of the Sun appear? Replace this text.

|  |  |  |  |
| --- | --- | --- | --- |
| Star | Luminosity (solar units) | Radius (solar units) | Surface Temperature (K) |
| Sun | 1.00 | 1.00 | 5800 |
| Star a | Replace me! | 0.10 | 5800 |
| Star b | Replace me! | 2.00 | 5800 |
| Star c | Replace me! | 1.00 | 11600 (or 12000) |
| Star d | Replace me! | 1.00 | 2900 |
| Star e | Replace me! | 100.00 | 2900 |
| Star f | Replace me! | 0.01 | 11600 (or 12000) |

3. (a) Considering the measurement uncertainty inherent in the data, do most of the points lie on (or near to) the Main Sequence line (within the Main Sequence strip)? Replace this text.

(b) Region A: Replace this text.

Region B: Replace this text.

Region C: Replace this text.

Region D: Replace this text.

What object's position is marked by the X? Replace this text.

What two lines intersect at this spot? Replace this text.

(c) The "Dwarfs (V)" label for the Main Sequence strip is unfortunate because the most luminous stars at the upper end of this strip have radii roughly replace this text times that of the Sun.

(d) Of the hundred nearest stars, only replace this text are obviously intrinsically brighter than the Sun.

(e) Move the cursor to the middle of the nearest star sample, where many of them are concentrated. This region is labeled replace this text on the diagram. The luminosities for these typical stars are replace this text that of the Sun's, their radii are replace this text that of the Sun's, and their surface temperatures are replace this text K.

(f) The nearest star sample shown is technically incomplete; at least five nearby white dwarfs were omitted. The most famous is the companion to the bright, nearby star Sirius A; Sirius B has a luminosity of 0.027 LSun and a surface temperature of 25,000 K. Moving the cursor to where this star would be plotted, its radius is replace this text that of the Sun's.

(g) Of these 150 brightest stars, only replace this text is/are intrinsically fainter than the Sun. While all the nearest stars were predominantly Main Sequence (V) stars, the brightest stars sample also includes many objects of luminosity classes replace this text and replace this text.

(h) Move the cursor to the star representing the most luminous star in this sample. Its luminosity is replace this text LSun, its radius is replace this text RSun, its surface temperature is replace this text K, and its B-V color is replace this text. The region where the cursor is now located is labeled replace this text on the diagram.

(i) Move the cursor to the star representing the largest star in this sample. Its luminosity is replace this text LSun, its radius is replace this text RSun, and its surface temperature replace this text K; its B-V color is replace this text. The region where the cursor is now located is labeled replace this text on the diagram.

(j) There are replace this text stars that are members of both samples (both nearest and brightest stars).

(k) In summary, the nearest / brightest (keep one) star sample is more representative of a typical volume of stars in our Galaxy, whereas the nearest / brightest (keep one) star sample is a specially selected sample, heavily weighted towards relatively rare, highly luminous objects.

The H-R Diagram for the Pleiades, a Young Star Cluster

1. If the Sun were to be viewed from larger and larger distances, it would appear brighter / fainter / unchanged (keep one). Its apparent magnitude would increase / decrease / remain unchanged (keep one), while its absolute magnitude would increase / decrease / remain unchanged (keep one).

2. (a) Identify the seven brightest Pleiades stars from their apparent V magnitudes: replace this text.

(b) The brightest cluster star is #replace this text, with an apparent V magnitude of replace this text.

If this star also has an apparent B magnitude of 2.78, and a B-V color index of -0.09, explain how the color index (the B-V color) was computed.

Replace this text.

(c) Star #1 is roughly replace this text times brighter than star #4.

(d) Star #replace this text is almost 100 times brighter than star #15.

3. If the stars in the Pleiades cluster lay only ten parsecs from Earth, they would appear brighter / fainter / unchanged (keep one), though their absolute magnitudes would be brighter / fainter / unchanged (keep one). Solar-type star #16 would have an apparent V magnitude of replace this text and would just be visible to the unaided eye as a faint star. Star #16 is actually much farther away than ten parsecs (it lies around replace this text parsecs away) so it appears much fainter: its actual apparent V magnitude is replace this text.

4. (a) As a star cluster ages, its Main Sequence turn-off point steadily becomes brighter / fainter (keep one) and bluer / redder (keep one). The masses of the stars around the turn-off point decrease / increase (keep one).

(b) The difference between absolute and apparent magnitude is the same for all members of the Pleiades cluster, because it is purely a function of the cluster distance from Earth. Use the absolute magnitude of the Sun and the apparent magnitude of solar-type star #16 to estimate this difference, and then determine the absolute magnitude of star #1, Alcyone (the brightest star in the Pleiades). Show your work, as well as stating your final answer.

For solar-type star #16 in the Pleiades cluster, absolute magnitude Mab = … and apparent magnitude Map = …

For all stars in the Pleiades cluster the difference Δ between absolute and apparent magnitude is defined as Mab ﹣ Map = Δ.

For star #16, Mab ﹣ Map = …, and so Δ = … for all Pleiades stars.

For star #1, Map = …

If Mab ﹣ Map = Δ, then we can solve this expression for Mab, defining Mab in terms of Map and Δ.

Mab = … (write Mab in terms of Map and Δ).

For star #1, Mab = ...

The brightest, bluest star still remaining on the Main Sequence is sometimes used to define a cluster's turn-off point. The term “turn-off” comes from recognizing that this star will be the next one to leave (or turn off) the Main Sequence, and become a red giant. For the Pleiades, this turn-off point is currently at absolute magnitude replace this text and B-V color replace this text.

(c) Locate star #14 (resembling Sirius) in Figure 6.4. There are only replace this text stars on the diagram that are brighter and bluer than it.

An H-R Diagram for M67, an Older Star Cluster

3. Insert your first figure here containing a copy of your list of 12 stars. Add a figure caption stating which star (identified by ID) is the solar-type star, and which stars fall into each of the other four categories of brightness and color.

6. (a) What happens if an aperture is too small? Where will the associated star appear on the H-R diagram, relative to its correct position?

Replace this text.

(b) What happens if an aperture is too large? Does it matter whether the extra space is dark sky, or contains a neighboring object?

Replace this text.

(c) What happens if the aperture is offset from the center of the star?

Replace this text.

(d) What happens if you place an aperture directly between two stars?

Replace this text.

Insert any extra figures here showing radial plots of counts to help with your answers to the following four questions. Be sure to add figure captions explaining each figure.

7. Discuss your results (your age estimate) for M67 below, explaining how you came to your conclusion. Note the particular features on the H-R diagram which were most important to your decision-making process.

Replace this text.

8. Compare your results for M67 with those for the Pleiades, with respect to the following five factors:

(a) Cluster turn-off point: Replace this text.

(b) Presence of red giants: Replace this text.

(c) Presence of red dwarfs: Replace this text.

(d) Presence of massive blue Main Sequence stars: Replace this text.

(e) Age of cluster: Replace this text.

Insert your second figure here showing the final H-R diagram. Be sure to add a figure caption explaining the figure.

Final (post-lab) Questions

1. How does the Sun compare to the other members of the nearest star sample? If one assumes this sample is representative of typical stars found throughout the universe, to what extent is the Sun a typical star?

Replace this text.

2. Consider the brightest stars in the sky, and why they appear so bright. Three students debate this issue. Student A: "These stars must be very close to us. That would make them appear brighter to us in the sky." Student B: "These stars are intrinsically very luminous, so they emit a tremendous amount of energy.'' Student C: "I think it's because these stars are very close and very luminous.'' Use what you've learned in this lab to support the views of one of the three students and answer the question "Why do the stars which appear the brightest in the night sky seem so bright?''

Replace this text.

3. Are these apparently bright stars very common (do stars like them make up a large percentage of all stars)? Explain your reasoning.

Replace this text.

4. Consider how the H-R diagram of the Pleiades would look far in the future.

(a) Suppose all of the Main Sequence stars above solar-type star #16 had run out of fuel and left the Main Sequence. What other regions in the diagram (besides the Main Sequence) would now be populated?

Replace this text.

(b) How old would this cluster be? Explain.

Replace this text.

5. The best explanation for why the H-R diagram for M67 does not include any white dwarf stars is (a) this cluster is not old enough for any of its stars to have evolved to this stage, or (b) the data this H-R diagram is based on only includes stars brighter than an apparent V magnitude of 16, and we expect any white dwarfs in M67 to be fainter than this. Explain your choice of answer.

Replace this text.

6. When measuring apparent magnitudes for stars in M67, if two equal-mass stars were tightly clustered in a binary system and could not be separated (they appeared as one star), where would their combined properties place them on the H-R diagram (versus where they would be placed if they were separable)?

Replace this text.

7. The constellation of Cancer contains the star cluster M44, which, like the Pleiades, is visible to the unaided eye on a clear night.

(a) Using its H-R diagram in Figure 6.5, compare this cluster's age with that of of the Pleiades and M67 clusters. Explain how you arrived at your conclusion.

Replace this text.

(b) Is M44 closer to or farther away from us than the Pleiades, and closer to or farther away from us than M67? Explain your answer.

Replace this text.

Summary (300 to 500 words)

Replace this text.

Extra Credit

Replace this text.