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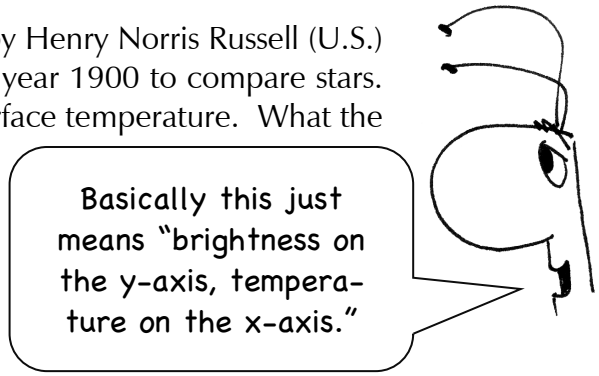
CA2 3.1: The Jewel Box: Lab

Purpose: To plot a basic Hertzprung-Russell diagram and note its features, as well as estimate the age of the Jewel Box cluster.

Background:
This activity is based on the "Jewel Box Cluster" activity developed by the National Optical Astronomy Observatory and is used with permission. The National Optical Astronomy Observatories web site for this project in its original version is located here: http://www.noao.edu/education/jewels/home.html. Color images of the cluster and measurement scales are required to complete this activity and can be found on the Teacher's Guide binder and can be downloaded from the site above.

H-R diagrams were independently invented by Henry Norris Russell (U.S.) and Ejnar Hertzprung (Denmark) around the year 1900 to compare stars. Basically they are a graph of luminosity vs. surface temperature. What the periodic table is to chemistry, the H-R diagram is to astronomy. They show the relationship between a star's intrinsic luminosity (how much light it emits) and its spectral class, color, and temperature. They are so informative and generally useful it is important you understand them thoroughly.



In this exercise, you will plot the color and brightness of a sample of stars from the Jewel Box Cluster to determine its approximate age.

Equipment needed: For this activity you will need:

- Color print of the Jewel box Cluster in a page protector (must be printed in color)
- washable or erasable marker
- Star Gauge (must be printed in color)
- graph sheet
- student answer sheet

Procedure:

1. Examine the print of the Jewel Box Cluster provided by your teacher. Do all the stars appear to be the same color?

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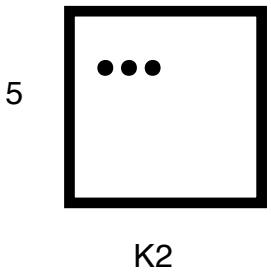
2. Estimate where the edge of the cluster lies. Make sure the color print of the cluster is inside a page protector so it can be used again. Outline (on the page protector) where you think the boundaries of the cluster are with the marker.

3. Place an "X" where you estimate the center of the cluster of stars to be and use a ruler to draw a 4 cm square about this center point. Measure the brightness of the star closest to the upper left hand corner of your square from its size in the image in comparison to the dots on the Star Gauge. Have your lab partner estimate the star's color using the color portion of the Star Gauge and place a filled-in dot on the graph provided in the box that corresponds to the brightness and color you have measured for your first star.

The Jewel Box Cluster. This is the picture you will be analyzing, but you must use a color version provided by your teacher.

Estimate how many stars are in the box.

Please note: you are not *plotting* the stars here. You are placing them in categorical *bins*. Each box on the chart corresponds to a star of a particular brightness and a specific color. The boxes are *containers* and you are putting a dot, representing a star, in a box. Thus, each box can hold several stars, and they should be drawn as separate dots so you can keep track of how many you have identified. For example, here is the box on the answer grid representing a star of color K2 (red) and size 5, containing 3 stars of that size and color you have located and classified so far.



Place a dot with your marker on the star you have just measured and then proceed in some systematic fashion to **measure and mark on your chart (on the last page of this activity) the brightness and color of every star within your 4 cm square.**

4. Do the Jewel box stars on your graph appear to be randomly scattered or do they fall in any kind of pattern?

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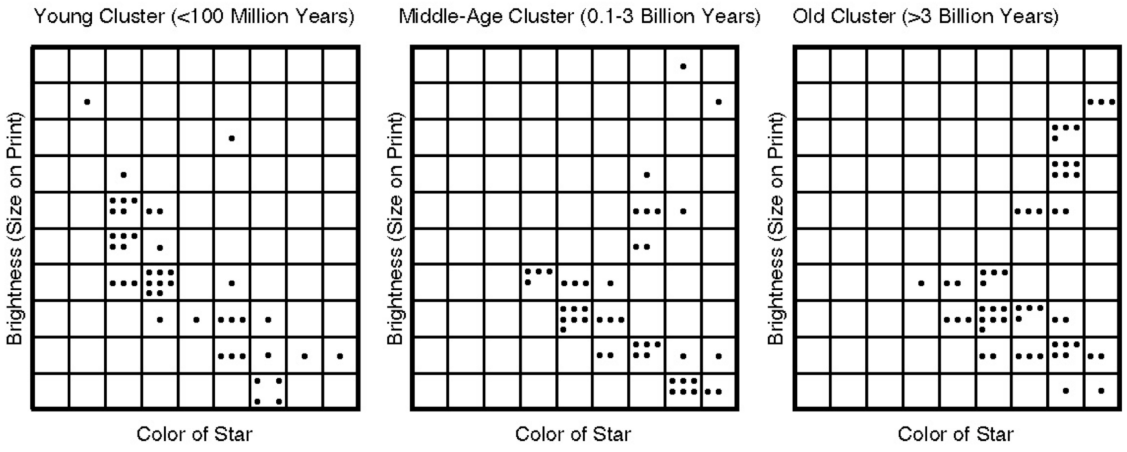
5. The reason astronomers like to analyze clusters is that it eliminates interfering variables when comparing stars. Presumably, all the stars in the cluster (not including the field stars) are at the same distance from us. What does that tell us about the bright stars in the image compared to the dim stars?

Another interfering variable that clusters control is *age*. The theory is all the stars in the cluster were formed more or less at the same time from the same nebula. Thus, differences between the stars are due to their intrinsic structural differences rather than distance from us or age. This includes things like the spectral class of the stars, their temperatures, overall luminosity, and so on.

Estimating the Age of the Jewel Box Cluster

Newly formed stars occupy a band in your graph from the upper left corner to the lower right corner. The most massive stars are hot (blue) and bright. The least massive stars are cooler (red) and dim. This band of stars is called the **main sequence.** Main sequence stars fuse hydrogen and are relatively stable. The sun is a main sequence star. Stars spend most of their "lives" on the main sequence.

The diagram below shows how the shape of the H-R diagram will change based on the age of the cluster.



When stars live out their lives and become old, the gravitational forces tend to collapse the star and internal heat forces that tend to expand a star get out of balance. This imbalance leads to the "death" of the star. When the most massive stars (the blue, giant stars) die, they will expand and cool, changing color and leaving the main sequence. The stars "peel off"

the main sequence from upper left, to lower right, in order. This forms an "elbow" on the diagram. The stars in the pointy corner of the elbow are about to die. If all the stars in the cluster were formed together, the "elbow" corresponds to the cluster's age.

6. Using the sample graphs on the graph worksheet, estimate the age of the Jewel Box Cluster.

7. Describe the visual appearance of a very old cluster.

8. What kind of diagram would result if we plotted stars selected randomly from all over the sky, and why?

Field Stars (Optional)

9. Stars in front or behind the Jewel Box that are not part of the cluster also appear in the image. Astronomers call these **field stars.** If time allows, estimate how many of these stars are included in your measurements by drawing a 4 cm square near the edge of the print and measure the color and brightness of the stars within this square. Mark these stars on your brightness-color diagram using an "x" instead of a dot.

Do the field stars appear to fall randomly on your diagram or do they appear to fall in any kind of pattern?

10. Compare your answer to Question 4 and Question 5. Why do you think the similarities or differences between the two star patterns exist?

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CA2 2C.3: Parallax of Stars: Activity

Plot your data on this chart.

Brightness (Size on Print)										
	1									
	2									
	3									
	4									
	5									
	6									
	7									
	8									
	9									
	10									
		O	B	A	F1	F2	G	K1	K2	M
	Color of Star									

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