IR Stars Experiment 1 - Ice as stars

SOURCE: http://bccp.lbl.gov/Academy/workshop3.html and
http://www.youtube.com/watch?v=R2Af_VMTxZY&feature=related

BACKGROUND

- In the video listed above, Cal Teach student assistant Kibeum Ryoo does an activity on infrared star detection with students at the 2009 BCCP Cosmology Workshop. Using an infrared thermometer, the experiment simulates Infrared Spectroscopy to illustrate the fundamental concept of black body radiation.
- In physics, Planck's law describes the spectral radiance of electromagnetic radiation at all wavelengths from a blackbody. Max Planck was a German physicist considered to be the founder of quantum theory, and was awarded the Nobel Prize in Physics in 1918.
- In this activity, students use an Infrared thermometer to simulate how infrared telescopes determine the temperature of stars. Students then create a chart of the data, creating a graphical representation of the data to illustrate the concept.
- Even though the demo is a 'backwards' representation as the ice cube stars will be colder than the surrounding space (and we are interested in the temperature differences only), it gives a good representation of measuring temperature and location of objects on the night sky.

MATERIALS

- PPT (OPTIONAL) showing the screen captures from the video
- Internet connection (OPTIONAL) and ability to show the above video, either before or after the experiment
- IR thermometers
- graph paper
- double-stick tape
- Pencils
- Rulers
- Cookie sheet or other shallow tray
- Ice
- dry ice
- oven mitts (to handle the dry ice)
- newspaper (to wrap dry ice in while in cooler)
- ice chest(s) or coolers
- students in teams of 4
- computer with Xcel software program
- blank pape

SET-UP

1. Place two sheets of graph paper on a flat shallow tray, such as a baking sheet. Be sure the lines match up. Use double-stick tape to hold sheets together so they don't slip.
2. Using a pencil and ruler, label the long horizontal "X" axis of a sheet of graph paper with Right Ascension (RA) coordinates and label the other vertical "Y" axis with Declination (DEC) coordinates. These will become the x- and y-axis on the graph paper and in the final chart of the data.
3. It is helpful to let one square on the graph paper be one degree in the sky.

OBTAIN DATA

1. Place a few cubes of ice on the sheet of graph paper. These will be the stars in the experiment. The example used 6 pieces of varying size.
2. Carefully trace a line around each star to mark its place on the graph paper. Number each of these to help keep each data point separate.
3. Aim the thermometer at one of the ice cubes and gets a reading from the thermometer. Be sure to hold the thermometer close to the area to be measured, with the large opening on the front aimed right at the temperature source. This reading of temperature will be the z-axis or "bubble size" on the final graph.
4. Record the star position through the center of the ice cube (RA, Dec), and the star's temperature (T) on a separate piece of paper.
5. Be sure to get readings for pointing the thermometer directly at the star, pointing the thermometer near the star, and pointing the thermometer far from each star (the graph paper, or "space").

GENERATE THE GRAPH

1. Using the hand-written data table listing coordinates and temperature for each data point, convert the RA degree numbers to a fraction of 15 degrees [eg. 0hr 6° becomes 0.4hr (6/15=0.4); 1hr 3.5° becomes 1.23hr (3.5/15=.23)]
2. Using an Excel spreadsheet, enter the data in columns – RA, Dec, Temperature on the star, Temperature near the star – for each star.
3. Be sure to save your work often.
4. Next, choose the bubble graph option for the data. We will assume spherical stars for this portion.
5. Click "*Select Data*."
6. In "*Chart Data Range*" box, click the small red arrow to the right.

7. Highlight all the cells containing data for RA, Dec, and both temperature readings. Ignore the space reading for now. The example has 6 rows and 4 columns, for 24 cells selected.
8. Click the red arrow again to return to the data source selection window. Notice *Series 1* and *Series 2* in the lower left part of the window.
9. Click once on *Series 1*. Click "*Edit*." Rename to "Temperature near the star."
10. Click red arrow next to *Series X values.* Highlight all the cells containing data for "RA" only (6 cells). Click red arrow to return.
11. Click red arrow next to *Series Y values.* Highlight all the cells containing data for "Dec" only (6 cells). Click red arrow to return.
12. Click red arrow next to *Series Bubble size.* Highlight all the cells containing data for "Temperature near the star" only (6 cells). Click red arrow to return.
13. Click OK.
14. Repeat steps 8-12 for Series 2. Rename it to "Temperature on (of) the star."
15. Click OK.

ADJUST THE GRAPH

1. Move the generated graph below the data table by clicking and dragging it around the sheet.
2. Right-click on the inner bubble (temp on the star), and select *Format Data Series.* Click *Series Options.*
3. Choose *Size Represents:* Width of Bubble, at *Scale Bubble Size*: 50% (in example). Notice the changes happening in the graph as you make changes in the pop-ups.
4. To get 3-d spheres with graded colors from yellow centers to purple edges - Click *Fill.* Select *Gradient Fill*. Choose *Type: Radiant*. Choose one of the *Preset colors: early sunset* (used in the example).
5. Remove two of the *Gradient Stops.* Adjust the remaining stops and colors till you get something that you like.
6. Repeat steps 2 to 5 for the outer bubble (temp near the star).
7. Click *Close*.
8. Under *Layout* tab, adjust *Chart Title*, and *Axis Titles*.
9. Use the *Data Labels* to label each of the data points Star #1, Star #2, etc.

ADJUST THE PRINTOUT

1. Using *Print Preview, Page Break Preview*, and *Page Set-up Options* adjust final printed size of data table and chart.

QUESTIONS

1. What does the graph tell you about how star interact with the space around them?

2. What does the graph tell you about the color of stars based on their temperature?

EXTENSION

1. Vary the "ice as stars" activity by adding dry ice for some of the stars.
2. Add frozen veggies like peas or corn, and frozen berries such as blueberries for some of the stars. Try some regular frozen, and try others that have been frozen by the dry ice.
3. Include this data in the data table and in the same graph described above.
4. What, if any, temperature difference(s) do you notice about these stars of different “composition”?