Teacher's Notes for

The Colour of Fire: An Astronomer's Tool

A GroundStation Canada Presentation of the H.R. MacMillan Space Centre

Program description: Have you ever wondered how astronomers obtain such detailed information about stars, which are so far away? This blazing 20-minute presentation will demonstrate the use of spectroscopy and how it applies to astronomy.

Advance preparation: Studies have shown that people, especially children, learn better when they feel secure in their surroundings and know what is expected of them. We recommend that you orient your students to the main areas of our facility, make sure the purpose of the field trip is clear and link the trip to the students' learning in the classroom. For a map of the facility and more suggestions for a successful field trip download the Orientation Package on our website www.hrmacmillanspacecentre.com.

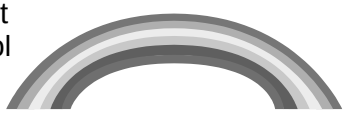
Curriculum connections: Grades 9, 11

Earth and Space Science IRP Connections:
G=GroundStation Canada Presentation
A=Teacher Guide activities

It is expected that students will:

Grade 9 Earth and Space Science	
describe the characteristics by which stars are classified	G/A
compare the life cycles of stars of different sizes	A
Grade 11 Earth Science: Astronomical Science	
demonstrate how spectra are used to determine the temperature, composition, and motion of a star	G/A
classify stars using a Hertzsprung-Russell diagram	G/A
describe the life cycles of stars	G/A

Activity One – Build Your Own Spectroscope (www.exploratorium.edu)



Introduction: Spectroscopy involves dissecting an object's light into its component colors or energies. A spectroscope is the tool used to separate light or energy into its component parts or spectra. Using spectroscopy, astronomers can infer the physical properties of celestial objects (such as temperature, mass, luminosity and composition).

Objective: Students will learn how to make a simple spectroscope.

Materials: a shoe box, a utility knife, a pencil, tape, elastics, index cards, diffraction grating (You can use the lens of 'rainbow glasses' which you can find at Science and novelty stores, or you can purchase diffraction grating from a Scientific Supply Company.)

What to do:

1. Using a pencil, draw a rectangle measuring about 2cm wide by 3.5cm high at one end of the shoebox. The rectangle should be roughly the size of one of the lenses in a pair of 'rainbow glasses'. This hole will be used for the diffraction grating.

2. Using the utility knife or scissors, cut around the rectangle. You may wish to start the hole with the utility knife and then finish the hole with the scissors.

3. The next step is to draw another rectangle on the opposite end of the box. This hole should be roughly the same size as the last one. Using the utility knife or scissors cut around the rectangle

4. Next, using your scissors cut one of the index cards in half. You will use each half of the index card to make a slit in the end of the box. Place the two halves of the index card over one of the holes, creating a vertical slit (about 3/16" wide). Tape these pieces in place using tape.

5. Next, cut out one eyepiece from the 'rainbow glasses' (or a piece of diffraction grating) and place it over the opening on the box. Lightly tape the diffraction grating in place.

6. Place the top on your box and place the elastics around the box to hold the top in place. Hold the box so that the slit is facing a light source. Making sure that the slit is oriented vertically. Now look through the diffraction grating into the box. You should see colors. If you used standard diffraction grating and you don't see the spectrum extending to both sides, the scratches on the grating are not parallel to the slit. Remove the diffraction grating and rotate it 90 degrees and try again. When the spectrum extends in both directions from the slit, securely tape the grating in place.

Using your Spectroscope: Students can now use this newly created spectroscope to compare the spectra of various light sources. When viewing different light sources, look for specific colors and notice the spacing between the colored lines. The heated

tungsten filament of an incandescent light bulb produces a continuous spectrum, where one color shades into another. The electrically excited mercury vapor in a fluorescent bulb produces distinct colored lines; the phosphors that coat the inside of the bulb produce a continuous spectrum.

Some other suggested light sources are a candle flame, the flame from a Bunsen burner, a flashlight, a Coleman lantern, yellow street lights (sodium produces the color), blue street lights (mercury vapor produces the color), neon signs, and slide projector lamps.

Different light sources produce different spectra. You can see the solar spectrum by looking at sunlight reflecting off a piece of white paper. DO NOT LOOK DIRECTLY AT THE SUN!

Activity Two – How Hot is That Star? (The Renaissance Centre, Tennessee)

Introduction: On a clear, dark night, you can tell that some stars are brighter than others. You can also tell that some stars shine with different colors. As it turns out – each star is different. Just like each person has a unique fingerprint – each star is different and has its own spectrum. In the early 1900's two scientists, Hertzsprung and Russell, came up with a way to organize all the stars in the sky into a simple chart. They believed that a star's temperature and luminosity (brightness) were related to each other, so they categorized thousands of stars into a chart comparing the two. Today, we call that chart the Hertzsprung-Russell (or HR) diagram. Each star is placed on the HR diagram according to how hot it is and how bright it is.

Objective: Students will create an HR Diagram as a vehicle to learn about stellar diversity.

Materials: scissors, crayons, markers, or colored pencils, glue or paste, black line originals of the HR Diagram (page 5-6)

What to do: Students will cut out and color representative samples of various types of stars. Students then build an HR Diagram by placing the star samples on a grid labeled for stellar temperature and luminosity. Students should understand the basic concepts of temperature, luminosity (brightness), and scale. Familiarity with graphs and charts is also helpful.

1. Take a look at the blank HR diagram. Notice that there are different categories along the top and along the left side. The top has different numbers that represent the temperature of a star in degrees Kelvin. (To convert from degrees Kelvin to degrees Fahrenheit, subtract 273, multiply by 9, divide by 5, then add 32. Otherwise, when working with the very high temperatures present in stars, it's really more important to focus on the relative differences in temperature, not the absolute values.) Along the left side of the graph, the numbers represent the brightness of a star – its luminosity.
2. Now cut out the star pictures. Notice that each one is a different size and there is a code printed on each one. One number is the temperature, the other is its luminosity (or brightness.) Each star also says what color it should be.
3. Color each of the stars, but make sure you can still see the numbers for temperature and luminosity.
4. Next, put each star on the HR-Diagram according to its temperature and luminosity. First, match the star's luminosity to the numbers on the left hand side of the graph.

Then, move the star over to the right until it falls under the correct temperature category. It's probably easiest to start with the largest stars and then work on the smaller stars. Some stars might overlap each other on the graph.

5. Label your graph "Hertzsprung-Russell Diagram" at the top, and put your name at the bottom.

Going Further:

6. Label your HR Diagram (one that you've made previously, or a completed diagram, included) using data from the following table. Match the Spectral Class with the temperature of the star.
7. Write a mnemonic (a way of remembering something) for the different spectral types: OBAFGKM. Write a sentence where the first letter of every word starts with each of the letters in the spectral types. One of the oldest examples is "O Be A Fine Guy, Kiss Me." Another example would be "One Bug Ate Five Green Killer Moths."
8. Study the HR Diagram, paying particular attention to the new information you have added.

Spectral Type	Approximate Surface Temperature
O	Greater than 44,000F / 25,000C
B	19,000F / 11,000C – 44,000F / 25,000C
A	13,000F / 7,000C – 19,000F / 11,000C
F	10,000F / 6,000C – 13,000F / 7,000C
G	9,000F / 5,000C – 10,000F / 6,000C
K	6,000F / 3,000C – 9,000F / 5,000C
M	Less than 6.000F / 3,000C

Resources

Spectra from Space
http://www.exploratorium.edu/spectra_from_space/

Excellent website for exploring the HR Diagram
http://www.smv.org/jims/l6.htm

H.R. MacMillan Space Centre (astronomical information)
www.hrmacmillanspacecentre.com