

## Solutions: Cosmic Colors and Spectroscopy

### Activity: Types of Spectra

Predictions: (write on board)

1. Observer with large, empty bucket:
  - a. What color balls will this observer have?  
*All of the red, yellow, green, violet balls, perhaps a small number of orange and blue balls*
  - b. Will this observer have an equal number of each color?  
*No – there will be many fewer orange and blue balls.*
  - c. What type of spectrum would this observer see, when looking at a hot, dense body through the cloud of gas?  
*Absorption (dark) line spectrum*
2. Other observers:
  - a. What color balls will these observers have?  
*Orange and Blue*
  - b. What type of spectrum would these observers see, when looking at the thin, excited gas?  
*Emission (bright) line spectrum*

Discussion:

3. Compare the results of the 'experiment' with the predictions.
4. Ask the students to predict what an observer would see if they were BETWEEN the hot dense body and the gas cloud:
  - a. looking towards the hot dense object  
*All the colors*
  - b. looking towards the gas cloud.  
*Emission (bright) line spectrum (blue & orange)*
5. Have the students suggest ways to improve the accuracy of this representation. For example, having the 'gas cloud' step up onto books of different heights depending on which ball they've caught, and then step down when they throw the ball would more accurately represent the changing energy state of the atoms in the cloud.
  - *Another point is that the atoms would only absorb photons (balls) of a PARTICULAR color of orange or blue (corresponding to a particular energy). If the balls were the full rainbow of colors, then most of the orange / blue colors would NOT be absorbed, but only certain shades of orange / blue*
  - *In reality, the gas cloud is made up of **many** atoms, so there should be more than one particle doing the absorbing...*

## Applications:

1. The Orion nebula is a bright cloud of gas and dust. It is visible to the naked eye as a fuzzy patch in the constellation of Orion. Hot stars form inside the nebula, and excite the thin gas of the nebula.

- a. What type of spectrum (continuous, emission-line, or absorption-line) would you expect the Orion nebula to have? Explain.

*The gas of the nebula is excited by the hot stars, so as the electrons lose energy, photons of particular energies / wavelengths are emitted (sent out), producing an emission (bright) line spectrum*

- b. The following spectrum of the Orion nebula was taken from: <http://www.pbs.org/wgbh/nova/origins/spectra.html>. Does this match your expectation?

*Yes, it is an emission (bright) line spectrum*

2. The centers of stars are hot and dense, but the outer layers are much cooler and thinner.

- a. What type of spectrum would you expect the Sun to have?

*Absorption (dark) line spectrum*

This image showing why stars have absorption-line spectra comes from:

<http://www.astro.columbia.edu/~archung/labs/spring2002/lab01.html>

- b. Explain why the Sun's spectrum has absorption lines.

*Even though the hot dense interior of the Sun gives off light (photons) of all colors, the outer layers of the Sun absorb some photons of particular wavelengths, exciting the gas. These photons are missing from the point of view of an observer on Earth, so we see dark lines in the spectrum.*

3. Each element can only absorb certain colors of light. The absorption spectrum of each element is like a “fingerprint”.

- Go to:

[http://www.ioncmaste.ca/homepage/resources/web\\_resources/CSA\\_Astro9/files/multi-media/unit2/stellar\\_spectra/stellar\\_spectra.swf](http://www.ioncmaste.ca/homepage/resources/web_resources/CSA_Astro9/files/multi-media/unit2/stellar_spectra/stellar_spectra.swf)

- Choose the “Classify Spectra” Activity

- a. What elements are present in the simplified spectrum of the Sun?

*Hydrogen, Helium, Sodium*

- b. What elements are present in the spectrum of Star A?

*Hydrogen, Helium, Calcium*

*Note: One of the Helium lines is not present in the spectrum of Star A, but others are. This can happen if the conditions of the Helium gas are unfavorable for the production of a particular line (e.g. wrong temperature)*

- c. What elements are present in the spectrum of Star B?

*Hydrogen, Sodium*

- d. What elements are present in the spectrum of Star C?

*Hydrogen, Helium, Sodium, Calcium, Mercury*