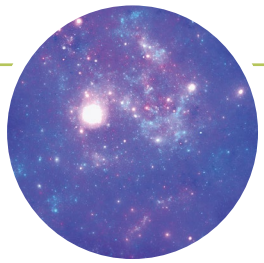
Determining the Age of a Star

A Carolina Essentials™ Demonstration



Overview

Use this activity as a student-based or teacher-led phenomenon for a unit on stellar evolution. Using an inexpensive spectroscope with wavelength units, students determine the visible spectrum for white light, hydrogen, helium, and a hydrogen/helium mixture. Spectral analysis guides students in determining the spectral pattern of medium-sized stars like our sun.

Earth and Space Science
Grades: 8–12

Phenomenon

Take a CD and rotate it around under a light. What do you notice?

White light should be broken up into the spectrum.

What do you think is causing the spectrum to appear?

Students may say that the CD is acting like a prism or some type of lens. A CD is constructed of 3 layers—2 plastic and 1 aluminum. One plastic layer is burned, so there are bumps called pits *and flat areas called* land*. A laser reads the pits and land as 1s and 0s, digitizing the medium. The burned plastic layer is coated with aluminum, making the shiny side we see. Another layer of plastic encases the aluminum. The shiny pits and land surface act similarly to a diffraction grating, which is a thin piece of plastic with many parallel slits. In both cases, the pits and slits diffract light, breaking it up into its component wavelengths.*

Essential Question

How does the composition of a star like our sun change over time?

Activity Objectives

1. Use the spectra of hydrogen and helium to identify and communicate the composition of a star.
2. Use the spectrum of a hydrogen/helium mixture to approximate the age of a star and describe where the star is in its life cycle.

Next Generation Science Standards* (NGSS)

HS-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information • Communicate scientific ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	**ESS1.A: The Universe and Its Stars** • The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.	**Energy and Matter** • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

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TIME REQUIREMENTS

PREP 15 min | **DEMONSTRATION** 20-30 min

Teacher Prep: 15 min
Demonstration: 20-30 min

SAFETY REQUIREMENTS

MATERIALS (PER GROUP)

CDs or CD pieces for the phenomenon
Colored pencil set (24 colors)
Economy spectroscope
Hydrogen spectrum tube
Helium spectrum tube
Hydrogen and helium spectrum tube
Spectrum tube power supply
High/low temperature gloves

HELPFUL LINKS

The Composition and Age of Stars
Periodic Table of Spectra Poster

REFERENCE KITS

Stellar Origin of the Elements

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Teacher Preparation and Disposal

Gather student spectroscopes and ensure that the diffraction grating is in place over the slit. Inspect the spectral tubes for any signs or cracks.

Student Procedure

1. Observe the hydrogen spectrum tube using the spectroscope.
2. Record the color bands you see, paying attention to the color, width, and brightness of each line.
3. Notice the numerical scale under the color bands. Estimate the wavelength for each color band and record the wavelength in nanometers.
4. Repeat the procedure with the helium spectrum tube.
5. Repeat the procedure with the hydrogen and helium tube.

Teacher Preparation and Tips

Instruct students on the use of the spectroscope by first looking at a fluorescent or incandescent light. On the wide side of the spectroscope, point out the narrow, vertical slit and larger opening that protects the diffraction grating. Instruct students to line up the light source in the narrow, vertical slit and then move their focus to the illuminated spectrum. It is critical that the light from the spectral tube is seen in the slit. Make sure they notice the wavelength scale.

Place the hydrogen tube in the power supply and turn it on. Darken the room if possible.

Have students record the colors of the spectrum and the associated wavelengths in nanometers.

Repeat with the helium tube.

Repeat the procedure with the hydrogen and helium tube.

Data and Observations

Hydrogen Spectrum

~400 nm ~700 nm

Helium Spectrum

~400 nm ~700 nm

Hydrogen and Helium Mix

Students may not record the exact same wavelengths for the colors they see. It's important to notice the additional colors in helium and that the mixture of the two elements produces a combined spectrum.

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Analysis and Discussion

1. Explain how the 3 spectra compare. *Hydrogen produces lines on the purple and blue end of the spectrum with one red band. Helium adds a yellow, green, and orange. The mix of elements produces a combined spectrum.*
2. If a star in the same class as our sun produced a spectrum similar to helium, what you would conclude about its age? *You would expect the star to be in the old stage. Helium is the product of hydrogen fusion. The hydrogen fuel would have been used up producing the helium.*
3. Explain what kind of spectrum you would expect our sun to produce in middle age. *You would expect both hydrogen and helium to appear in the spectrum. Some hydrogen would have already fused to make helium, but there would still be a supply of hydrogen. The spectrum would show both hydrogen and helium.*
4. Using the spectra, illustrate the life cycle of our sun. *Young: hydrogen spectrum. Middle age: combined spectrum. Old: helium spectrum.*

TEACHER NOTES

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