

Link to Website: [Student Exploration: Star Spectra](#)

Prior Knowledge Questions

1. Why is it that spectra can help us identify what elements an object is made of?

Different elements each interact with a different set of wavelengths to create unique spectra. They can often overlap partially though, so just one or two wavelengths are not enough of a match to be certain of an element's presence.

2. If a star contains an element, how many of the element's bands should be in the star's spectra?

ALL of an element's wavelengths should be present, which means as soon as one is missing you can conclude that it is probably a different element.

3. From chemistry class, what is an ion? What has changed about an atom to make it an ion?

I ask this question because the Gizmo uses both neutral and ionized spectra, so I want to make sure students are familiar with the word. An **ion** is an atom / molecule that has a charge; positive or negative. Ions are typically created through the loss or addition of electrons.

*At this point you will start to use the simulation. Once you log in, Click **Show Labels** in the top left corner. To view a star's spectra, click on that star. You can drag elemental spectra from the right side of the screen to the star's spectra to compare and contrast. There are two versions of most elemental spectra: **Neutral Spectra** and **Ionic Spectra**. They are different from each other, so make sure you click the options in the top right to switch between the two versions. You will need to test both versions at times.*

Activity A: Classifying Stars

Question: How are stars classified?

Introduction: Late in the 19th century, Harvard astronomer Edward Pickering wanted to sort and catalog the thousands of star spectra that had been collected by the Harvard Observatory. He hired several women to do the work, paying them 25 cents a day (about \$70/day in today's money). The most prominent of these women was Annie Jump Cannon, who devised a classification system still used today.

(Please go to the next page)

4. Directions: Work with your partner to fill out the table for the stars 1-4. Maybe you do two stars and your partner focuses on the other two. You will need to use the classification scheme in the table below. I would start by looking at your star's color and use the table as a hint of which elements to check.

Harvard Classification Scheme			
Class	Color	Prominent spectral lines	Surface Temp. (K)
O	Blue	Ionic helium, hydrogen	> 25,000
B	Blue-white	Neutral helium, hydrogen	11,000 – 25,000
A	White	Hydrogen, ionic sodium, ionic calcium	7,500 – 11,000
F	White	Hydrogen, ionic sodium and calcium; neutral sodium and calcium	6,000 – 7,500
G	Yellow	Neutral sodium and calcium, ionic calcium, ionic iron, ionic magnesium	5,000 – 6,000
K	Orange	Neutral calcium, neutral iron, neutral magnesium	3,500 – 5,000
M	Red	Neutral iron, neutral magnesium, and neutral titanium oxide (not shown)	< 3,500

Star Number	Star's Color	Elemental Composition	Class
1	Blue White	Hydrogen, Neutral Helium	B
2	Orange	Neutral Calcium, Neutral Iron, Neutral Magnesium	K
3	Blue	Hydrogen, Ionic Helium	O
4	White	Hydrogen, Ionic Sodium, Ionic Calcium (But NOT neutral sodium, nor neutral calcium so it's class is A)	A

Activity B: Unusual Stars

5. On the next page, your pair will focus on one of the stars 5-10. First read through the descriptions of uncommon stars and figure out which description matches your star's spectra. Then using the description and the class table above, figure out your star's color, composition, class, and unique feature. *These uncommon stars often do NOT include their typical ingredients, and may be harder to read their spectra.*

Uncommon Star Descriptions

- A. High atmospheric pressures in a star cause spectral lines to be broadened, or “smeared out.” **Giant stars**, which have relatively low atmospheric pressures, are characterized by narrow spectral lines.
- B. A **nebula** is an enormous cloud of gas and dust in which stars are born. Most nebulae produce an **emission spectrum**, which is characterized by bright lines of color against a dark background. The bright lines in an emission spectrum correspond to the dark lines in an absorption spectrum.
- C. A star orbited by a large planet will move in a small circle. This will cause its spectrum to be slightly redshifted part of the time and blueshifted at other times.
- D. **Binary stars** are pairs of stars that orbit one another. Their presence is indicated by two spectra that shift in opposite directions.
- E. **Cepheid variable** stars change their brightness in a regular cycle. Gas pressure builds up, causing the stars to expand quickly. When the pressure is released, the star contracts, and the intensity of some spectral lines may decrease.
- F. If a star is moving away from an observer, spectral lines are **redshifted**, or shifted toward the red end of the spectrum. An approaching star is **blueshifted**.

(You need to fill in the row for your pair's star. Other groups will help you fill in the other rows)

Star	Color	Elements in spectrum	Class	Unusual features
5	White	Hydrogen, Neutral Sodium	F	Redshifted Star - Spectra are all slightly moved to the “right” / Red side
6	Red	Neutral Iron, Neutral Calcium	M	Giant Star - Bands in the spectra are narrower than usual
7	Greenish ?	Hydrogen, Neutral Helium, Neutral Sodium	NA Not a star	Nebula - This “star” is not a star but a cloud-like structure in space. The thin density leads to the emission spectrum instead of absorption spectrum
8	Yellow	Neutral Calcium, Ionic Iron	G	Cepheid Variable Star - Stars like these change pressure, volume, and this brightness cyclically
9	White	Hydrogen, Neutral Sodium	F	Binary Star System - This “star” is actually two stars that orbit each other and redshift / blueshift as a result.
10	Yellow	Ionic Calcium, Neutral Sodium	G	Exoplanet Star (C) - Some stars have a close but large planet orbiting them that causes the star to move enough for us to see them redshift / blueshift.

6. (Wait until we finish sharing to do this question together)

Other than your star's unique feature, what other unique feature that is visible in a star's spectra did you find most interesting and why?

Many of the students thought that the binary stars were interesting, but what is important is that they pick something from today and use their science vocabulary to express some detail about it. I wanted to give them some agency to talk about whatever interested them to let them practice, but also to let me see what kinds of things interest them for later.