Lab 2 – Identifying Atomic Spectra

ASTR 1020

Name:

Overview:

In this activity you will explore how different types of spectra are made and get a brief overview of what instrument astronomers use to record spectra. You will also identify unknown spectra and match them to space environments.

Objectives:

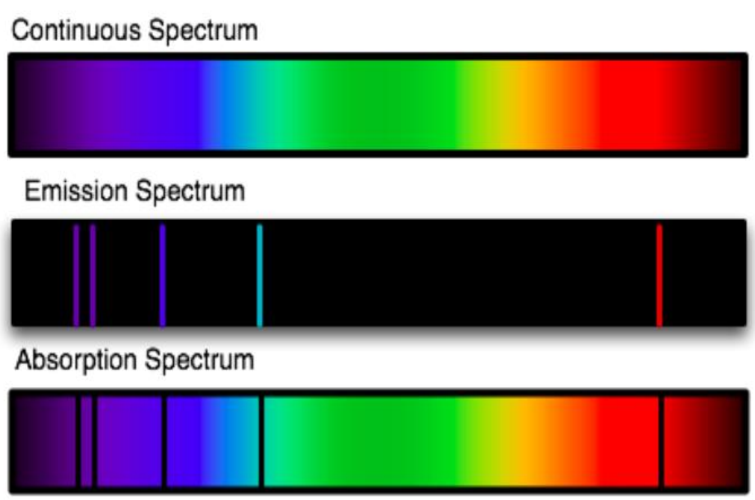
After completing this activity, students will be able to:

- Identify different types of spectra
- Visualize how a spectrograph can be used to create a spectrum.
- Identify the elements in an unknown sample by comparing it to the spectra of known objects.

Definitions

Here are some terms from lecture that we will be using today in lab:

- **Spectrum** – a band of colors, as seen in a rainbow, produced by separation of the components of light by their different degrees of refraction according to wavelength.
- **Continuous spectrum** – a spectrum that consists of light at all wavelengths without interruption. Hot, dense objects like a light bulb or CORE of a star produce continuous spectra.

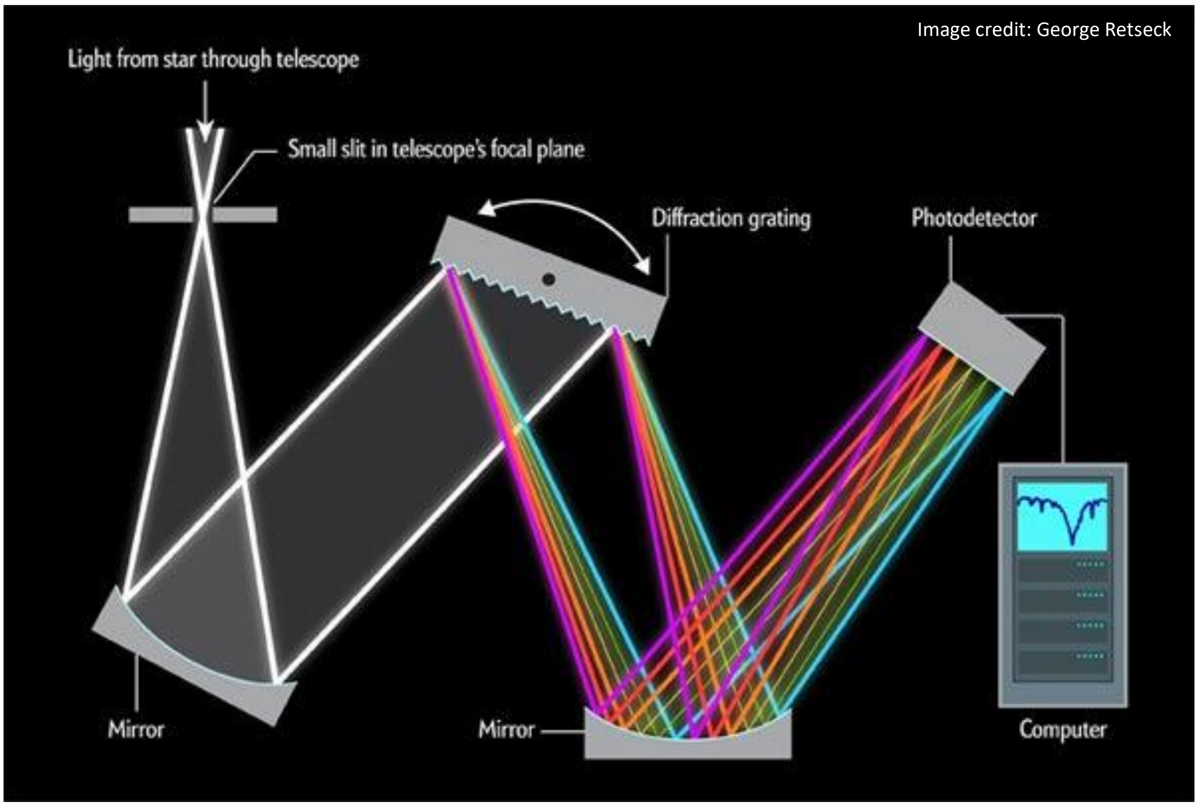


- **Emission spectrum** – a spectrum that only emits light at specific wavelengths, forming a pattern similar to a colorful bar code. Hot gases produce emission spectra.
- **Absorption spectrum** – a spectrum that looks like a rainbow with black lines removed at specific wavelengths. They are created when the light of an object that produces a continuous spectrum passes through a cloud of cool gas.
- **Spectrograph** – an instrument that uses a prism or diffraction grating to split light into its component wavelengths.

- **<u>Diffraction grating</u>** – an optical component, typically made of glass or metal, a marked with very close parallel lines. When light hits these lines, light of different wavelengths bounces off in different directions, producing a spectrum.

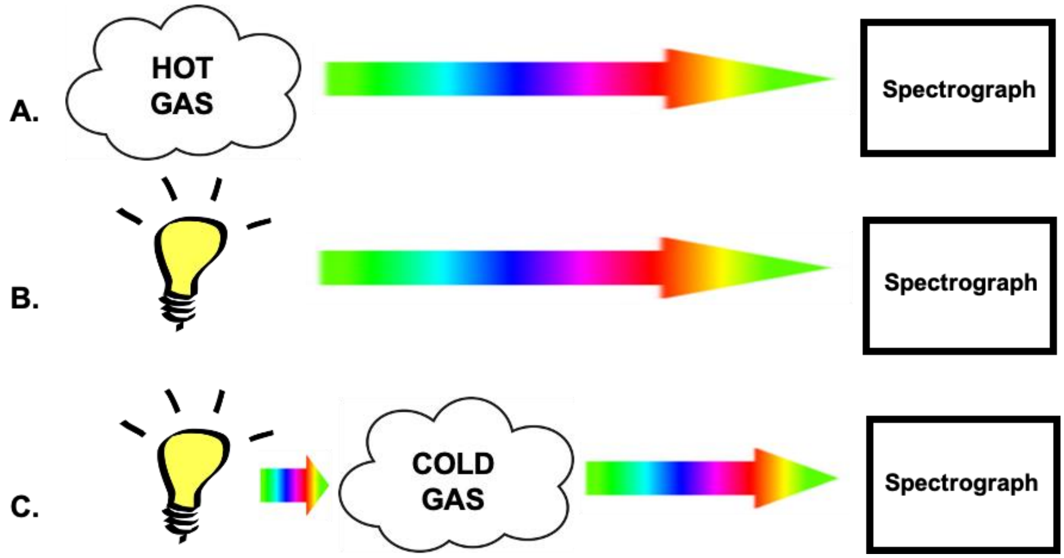
<u>Part 1: Making and Identifying Spectra</u>

In order to observe the spectrum of an object in space, a spectrograph needs to be attached to your telescope. The process begins with light from the star, galaxy, planet, or whatever you are looking at, enters though the telescope. The light is sent through a small slit so the light rays can be collimated (made parallel to each other). The parallel light rays bounce off a mirror and are sent to the diffraction grating. When the light encounters the small groove cut into the grating, lights of different wavelengths bounce off in slightly different directions, separating the light into its component wavelengths. The separated light bounces off another mirror into the detector. You now have a spectrum!



Now that you know how a spectrum is produced, you need to identify what situations create what types of spectra!

Below are three scenarios of light traveling to your spectrograph. Identify what type of spectrum (continuous, emission, or absorption) would be produced in each situation.

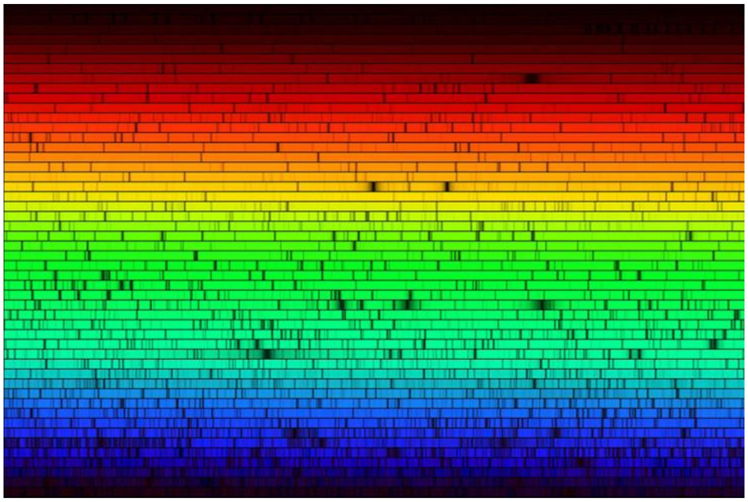


1. In Figure A, light from a hot gas enters a spectrograph. What type of spectrum will it produce?

2. In Figure B, light from a hot dense object enters a spectrograph. What type of spectrum will it produce?

3. In Figure C, light from a hot, dense object that has passed through a cold gas cloud enters a spectrograph. What type of spectrum will it produce?

Here is a spectrum of the Sun (image credit: N.A. Sharp, NOAO/NSO/Kitt Peak FTS/AURA/NSF).



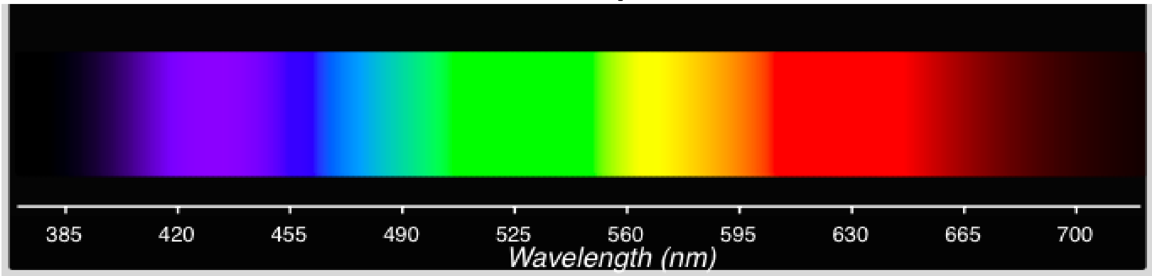
4. What type of spectrum does the Sun produce – emission or absorption?

5. Why do we see this type of spectrum rather than a continuous spectrum?

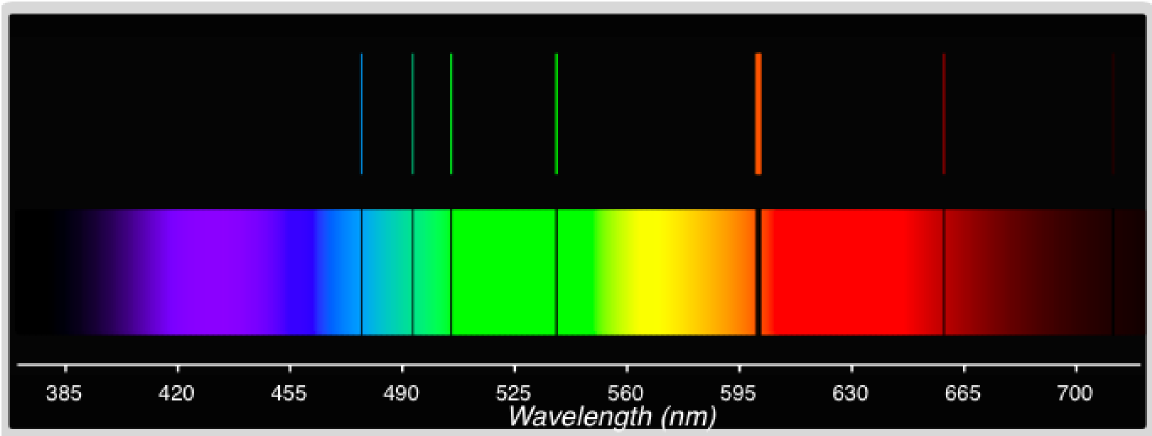
Part 2: Example Spectra

You will use the following absorption (bottom) and emission (top) spectra to answer the questions in section II. This list includes 8 of the 10 most abundant elements in the universe; the remaining two are neon and magnesium, for those students who are interested. They are listed in alphabetical order, but we will start with a continuous spectrum.

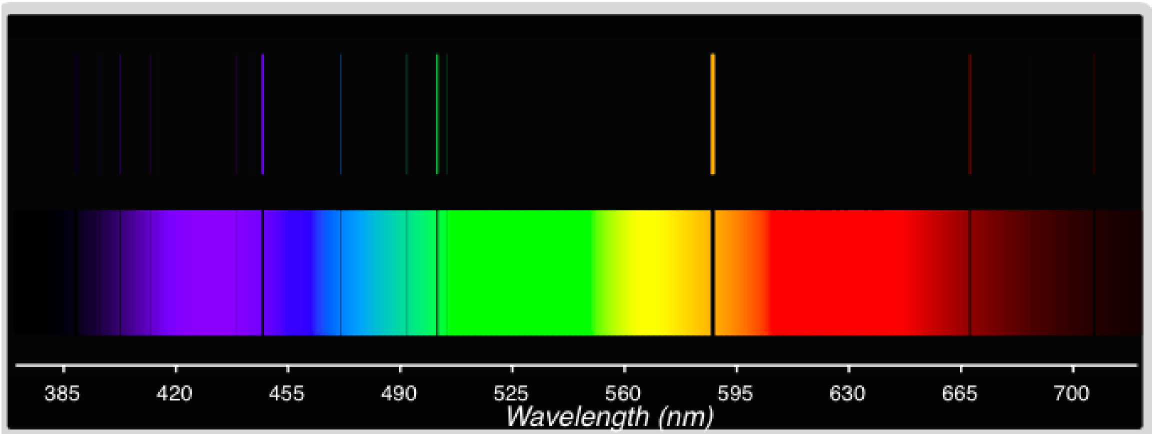
Continuous Spectrum



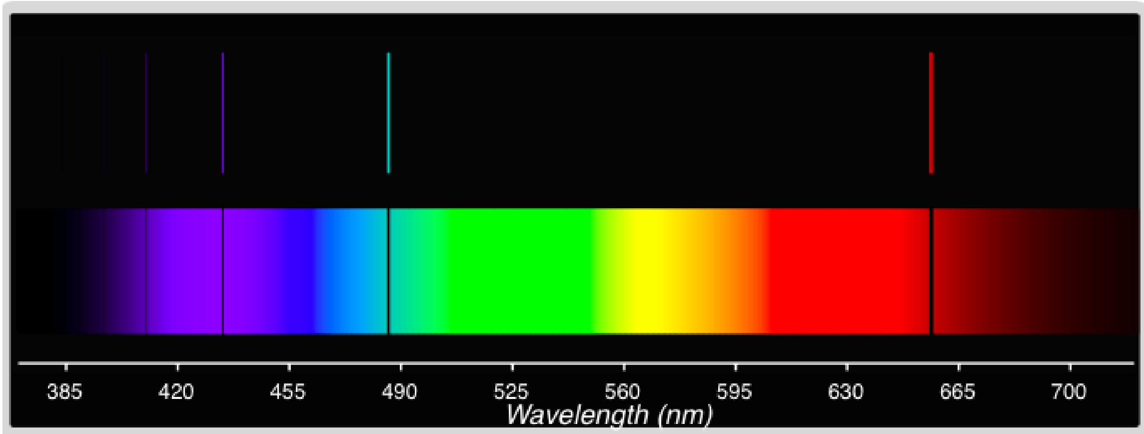
Carbon



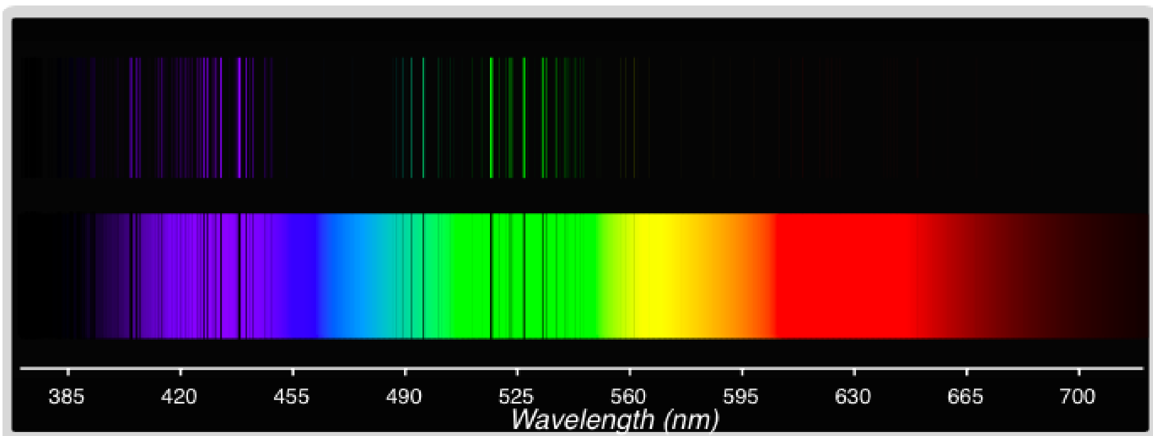
Helium



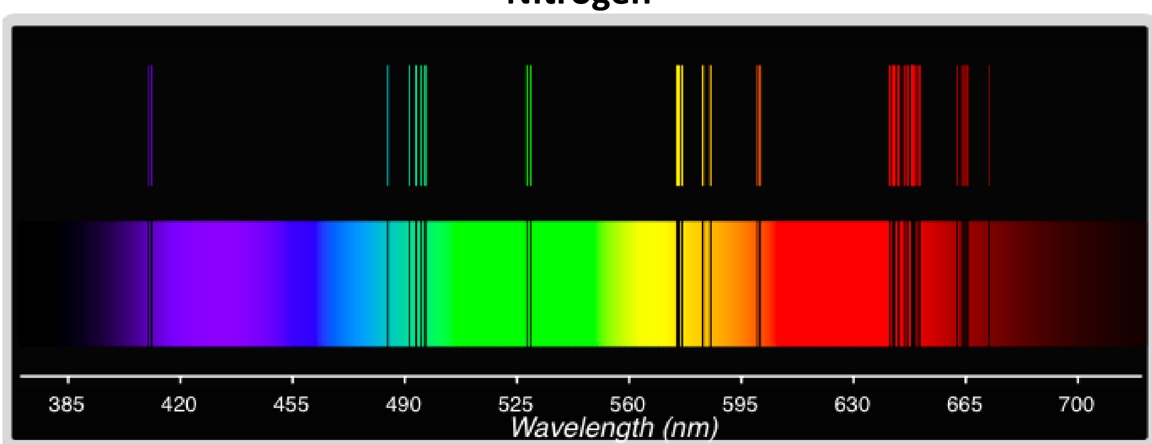
Hydrogen



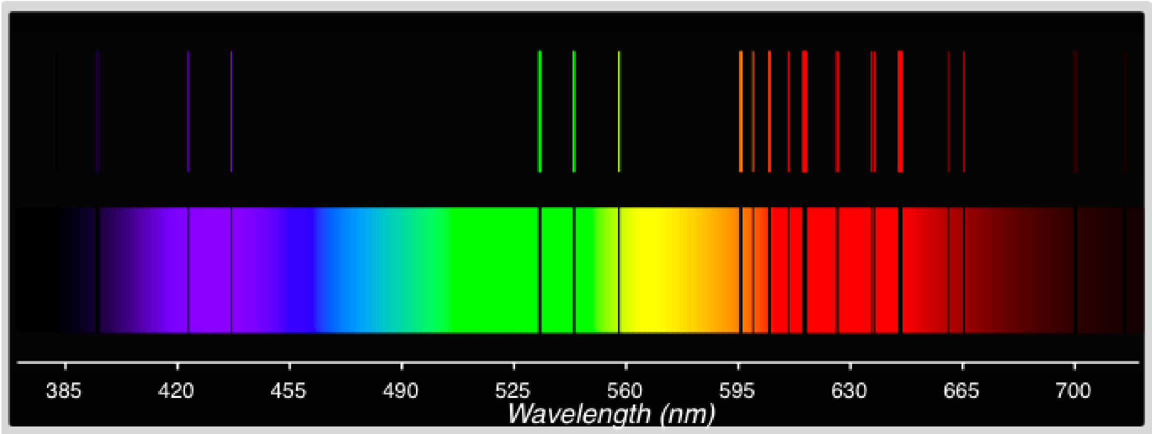
Iron



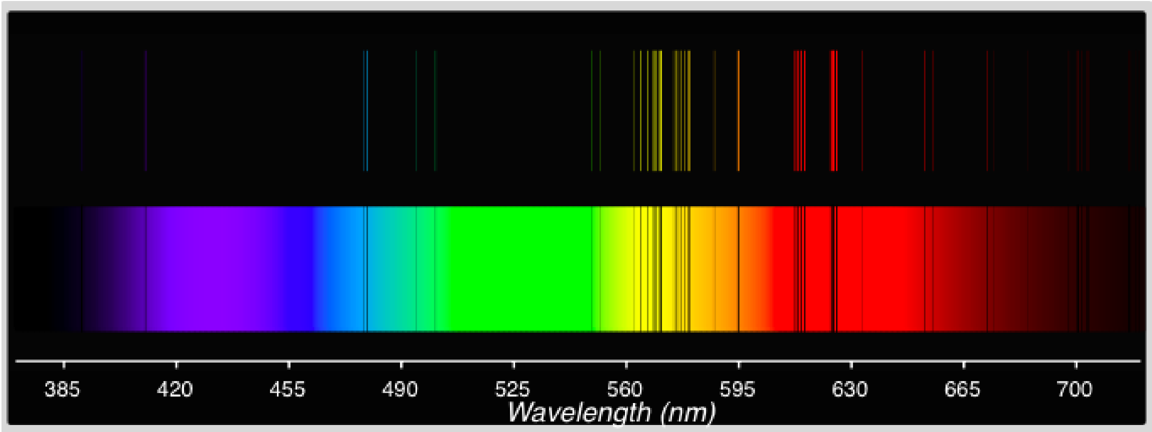
Nitrogen



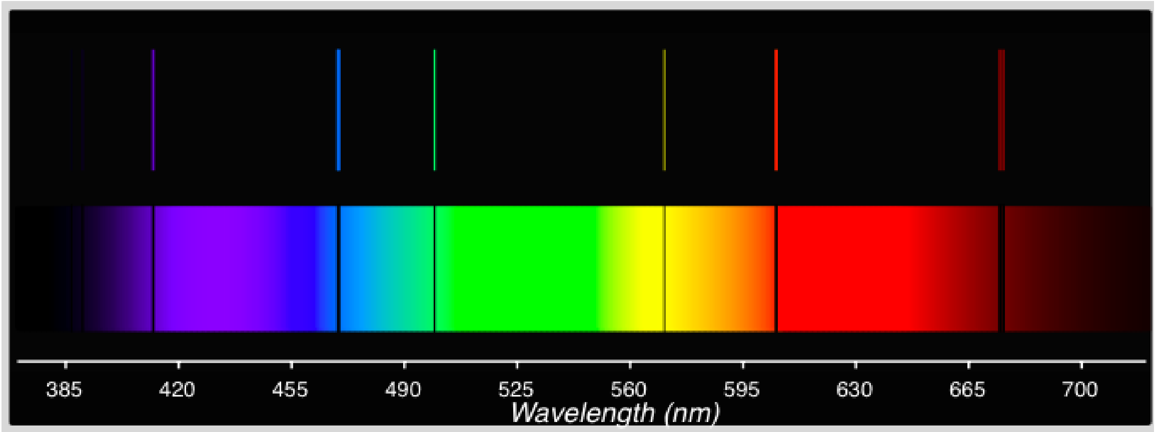
Oxygen



Silicon



Sulfur

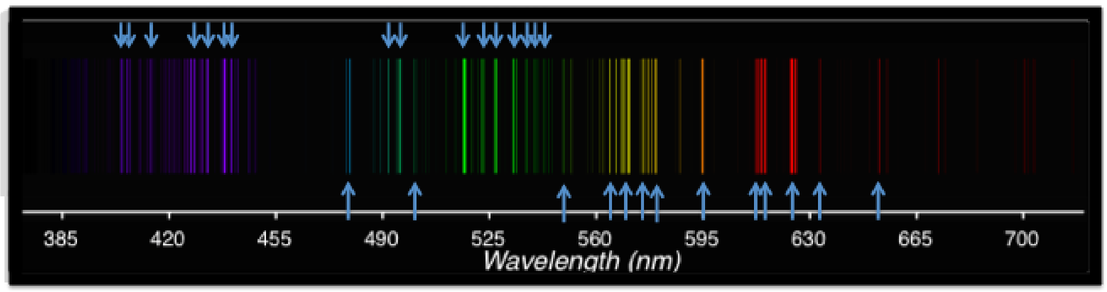


You will use these spectra to complete Part 3. You can find a pdf with just the spectra in the 'Identifying Atomic Spectra' module in iCollege (to avoid scrolling back and forth, download the spectra pdf and resize the windows so they are side-by-side!).

Part 3: Identifying Unknown Spectra!

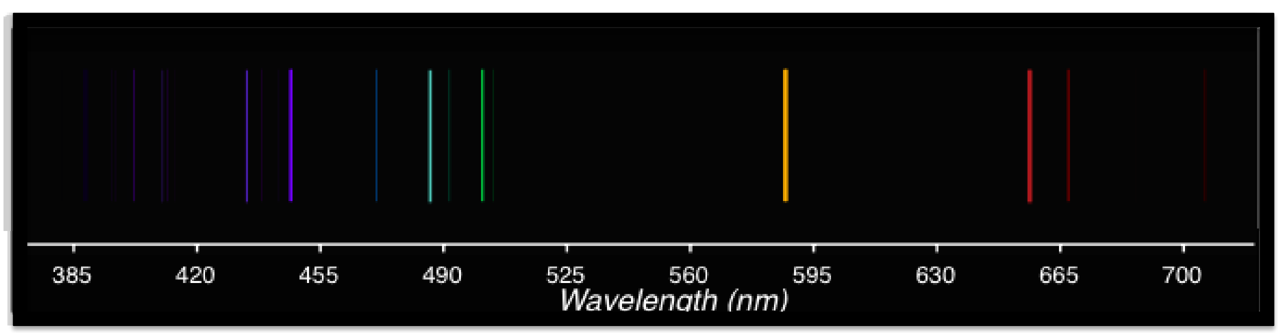
In this section you will need to identify what elements are present in eight unknown objects. There will be either two or three elements present in every sample. Use the known spectra in Part 2 to identify them; the lines in the examples may be somewhat brighter or fainter than the ones shown here but will always be shown at the same wavelength on the horizontal axis.

An example of what you are expected to do is shown below and your TA will walk you through identifying this example in the lab video on iCollege.



- Element 1: *Iron (top arrows)*
- Element 2: *Silicon (bottom arrows)*

Unknown Object #1 (two elements present)

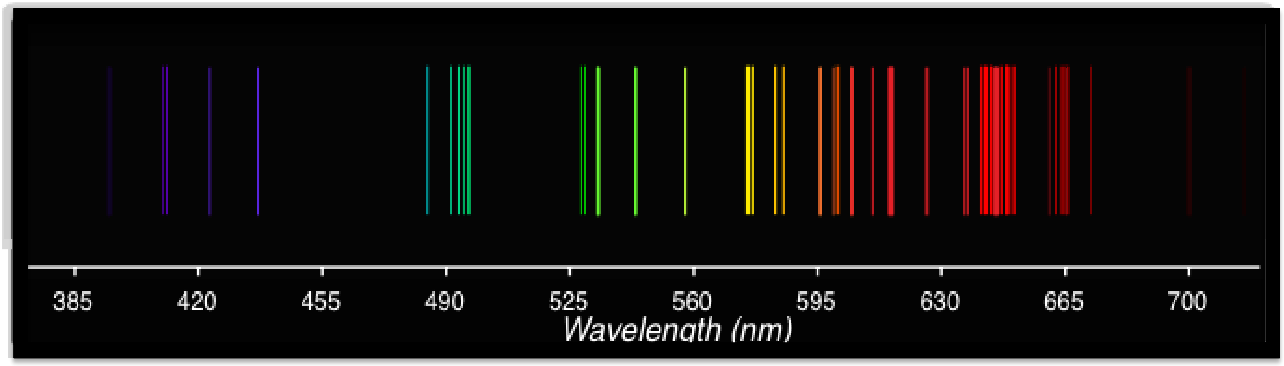


6. Elements in Unknown Object #1:

Element 1 –

Element 2 –

Unknown Object #2 (two elements present)

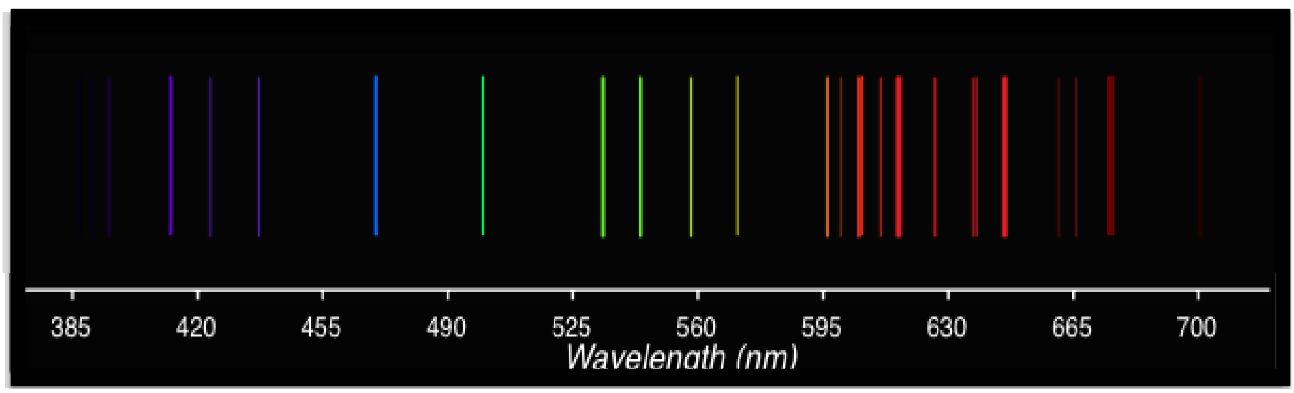


7. Elements in Unknown Object #2:

Element 1 –

Element 2 –

Unknown Object #3 (two elements present)

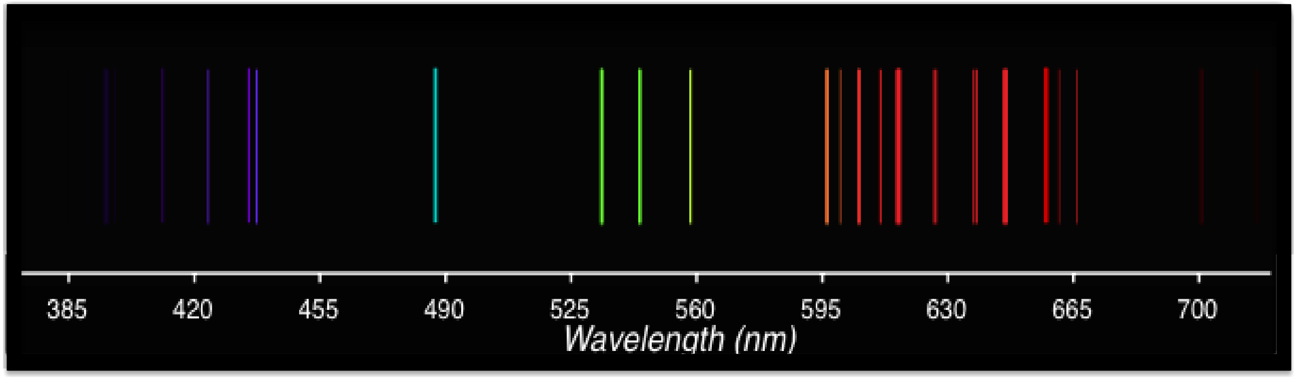


8. Elements in Unknown Object #3:

Element 1 –

Element 2 –

Unknown Object #4 (two elements present)

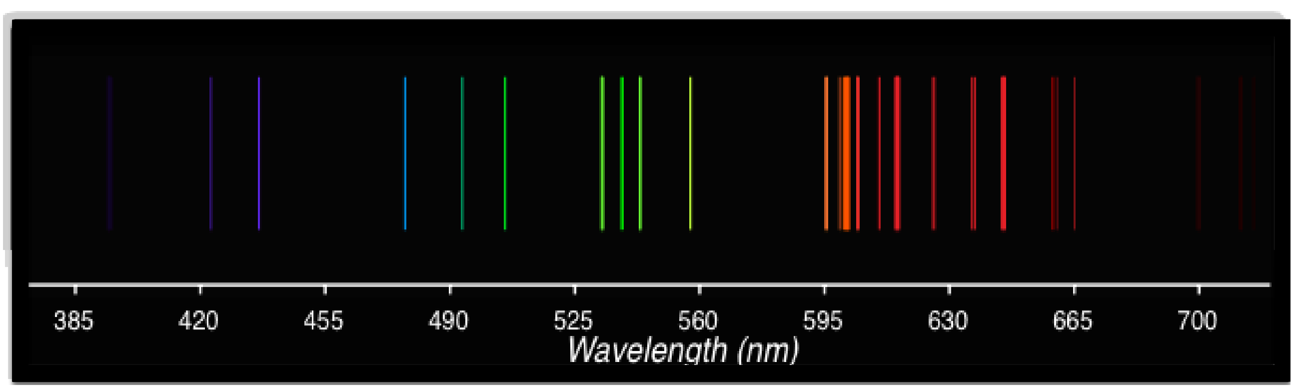


9. Elements in Unknown Object #4:

Element 1 –

Element 2 –

Unknown Object #5 (two elements present)

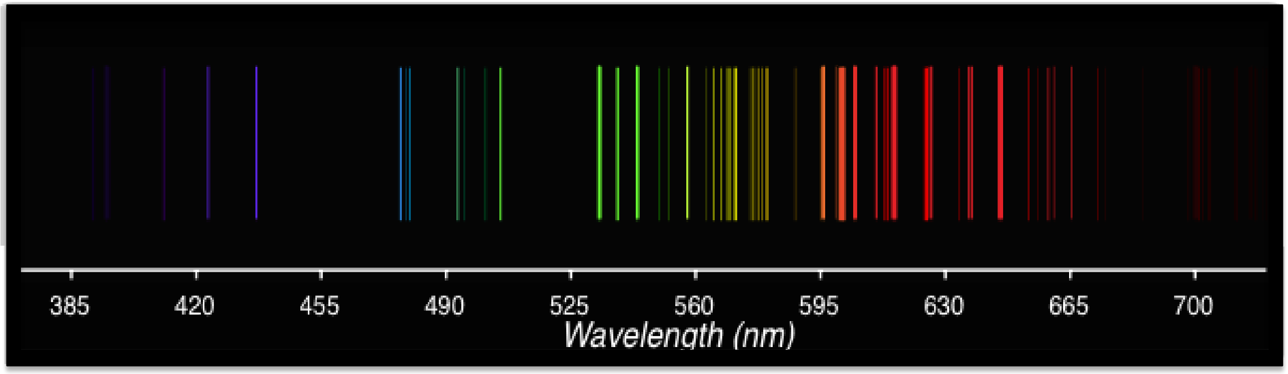


10. Elements in Unknown Object #5:

Element 1 –

Element 2 –

Unknown Object #6 (three elements present)



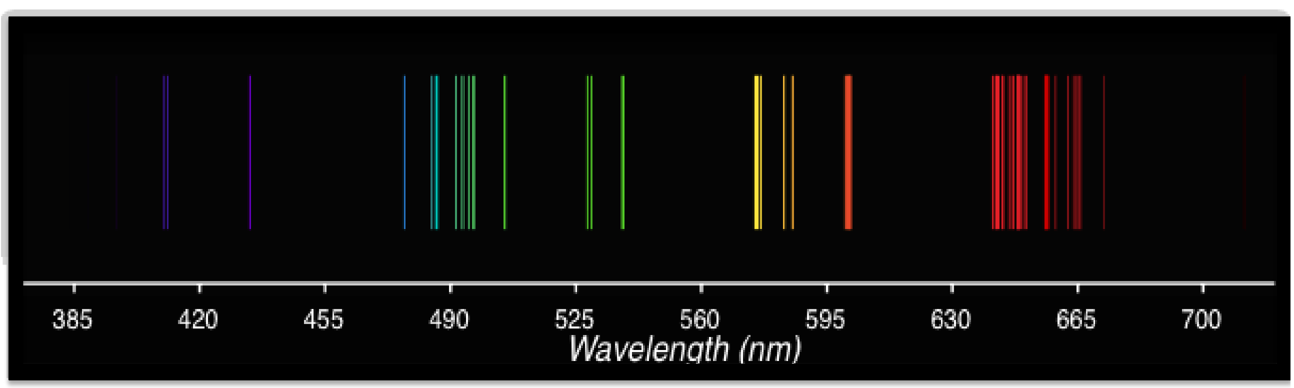
11. Elements in Unknown Object #6:

Element 1 –

Element 2 –

Element 3 –

Unknown Object #7 (three elements present)



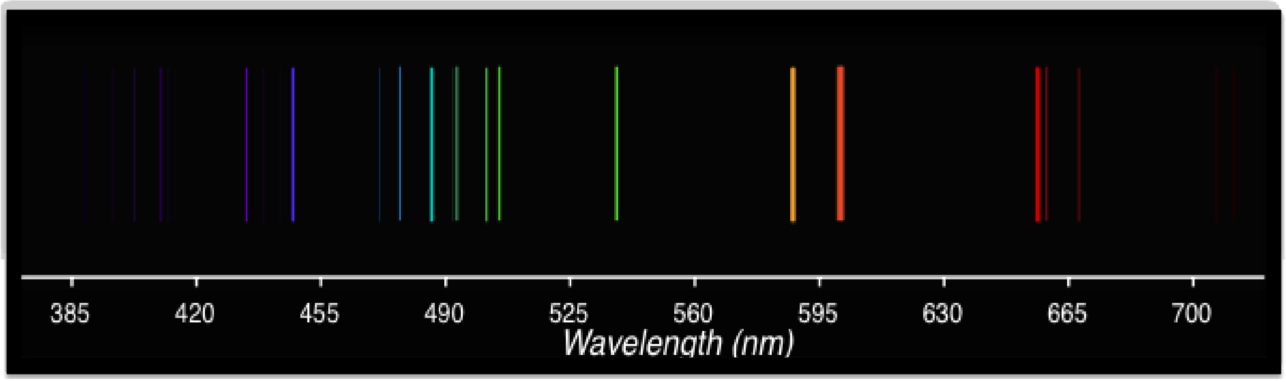
12. Elements in Unknown Object #7:

Element 1 –

Element 2 –

Element 3 –

Unknown Object #8 (three elements present)



13. Elements in Unknown Object #8:

Element 1 –

Element 2 –

Element 3 –

Part 4: Matching Unknown Objects to Space Environments

The final section of this lab lists eight environments (see Table 1) from which astronomers have obtained spectra. While most of these environments would produce absorption spectra, as you saw in Part 2 of the lab both absorption and emission spectra present spectral lines at the same wavelengths.

There are 8 environments listed below in Table 1. Determine which of the following environments show a chemical composition most similar to the unknown spectra you identified in Part 3. In Table 1, write the number of each sample next to the correct environment. **Note**. Each unknown object (1-8) will only be used once!

Be aware that this lab has been simplified quite a bit to help you complete the lab in a timely fashion. For example, water (H_2O) has more spectral lines than just those of hydrogen and oxygen superimposed upon each other. We have ignored these extra lines, however, so that you can more easily identify the elements that are present in the unknown samples through comparison to single-element spectra. This does not detract from the validity of the technique you are learning – you should just acknowledge that the task is harder for scientists using raw data. Ask your TA, they may be able to regale you with tales of identifying spectral features!

Finally, most of the objects listed below have many elements in their compositions. We are only focusing on the most abundant two or three elements and have ignored the spectral lines of less abundant ones.

Table 1. Matching Unknown Objects to Outer Space Environments

Unknown Object	Matching Environment
	A. Interstellar dust – silicate oxides (SiO) & silicon carbide (SiC)
	B. A comet – water ice (H_2O)
	C. Earth's atmosphere – molecular nitrogen (N_2) and oxygen (O_2)
	D. The surface of a star – H and He gas.
	E. Titan's atmosphere – nitrogen (N) and carbon dioxide (CO_2)
	F. The surface of Io – sulfur (S) and sulfur dioxide (SO_2)
	G. Venus' atmosphere – carbon dioxide (CO_2)
	H. Uranus' atmosphere – hydrogen (H), helium (He) & methane (CH_4).

To complete this assignment for grading:

- File → Save As… → Rename the file 'YourLastName – SpectraLab'
- Upload to the file to the 'Lab 1 – Identifying Atomic Spectra' assignment in iCollege (click Add Attachments → Upload → upload renamed saved file → Update).
- Complete the Reflection activity on iCollege