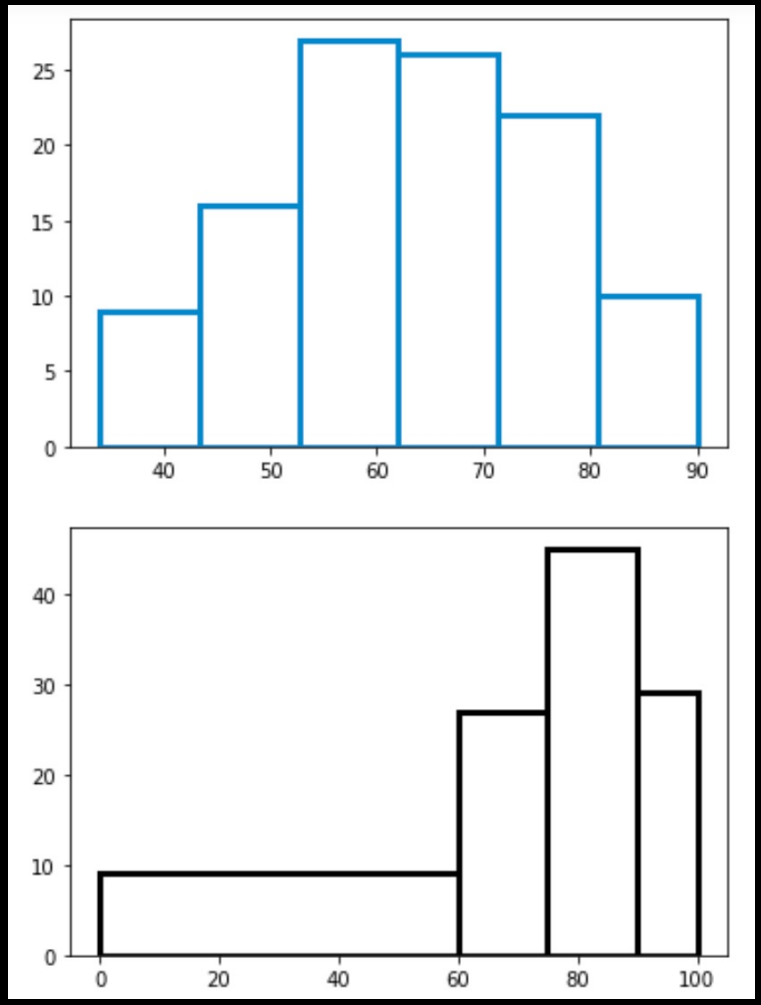
Results from Midterm 1

- If you missed Midterm 1 for any reason, make up is April 14.
- Lowest of 3 scores will be dropped when computing your midterm average.
- All course materials will be again on the Final.
- Curved average of Midterm 1 is a B, around 80%.
- Midterm 1 and key will be posted on Blackboard this Friday.

raw percentage



curved: D C B A

Astronomy 100
Chapter 7

Atoms and Spectra
(Or: how we study the universe using light)

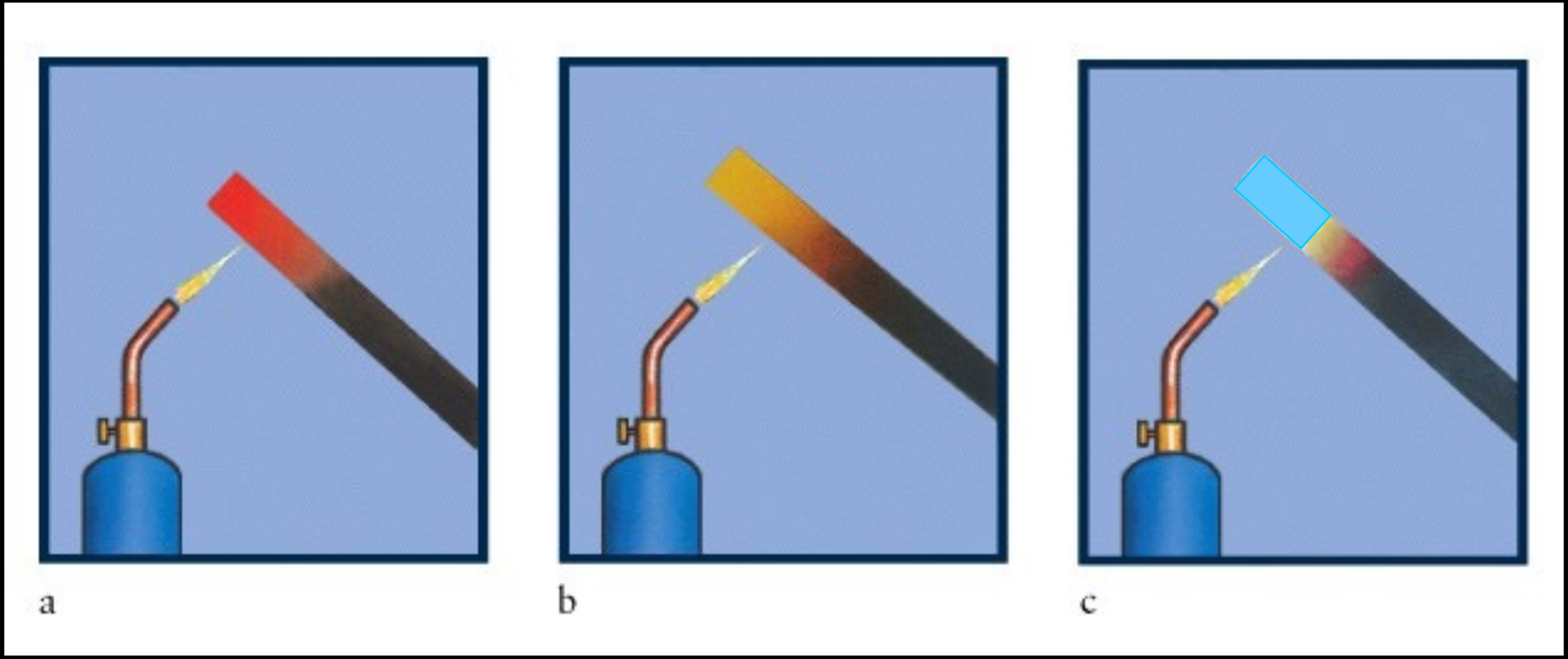
Vera Gluscevic

Plan for this lesson:

Temperature
Blackbody
Atoms
Absorption and emission
Redshift

Temperature

Which object is hotter, an object that is emitting mainly red light or mainly blue light?



increasing temperature

Luminosity is the total energy (light) emitted by an object in each second.

Our Sun has a luminosity of 3.8×10^{26} watts.

Stefan-Boltzmann law:

Luminosity depends on surface area (A) and temperature (T)

Luminosity = $5.67 \times 10^{-8} \times$ **A x T^4**

- Big and Hot objects have greater luminosity than small cool objects.

question for you

Star A and star B have the same luminosity. If star A is 2 times cooler than star B, how do their sizes compare?

A. There is not enough information to infer this; we would also need to know their distances.
B. Star B has 2 times larger surface area than star A.
C. Star A has 16 times larger surface area than star B.
D. Their sizes are the same, if their luminosities are the same.
E. I have no idea.

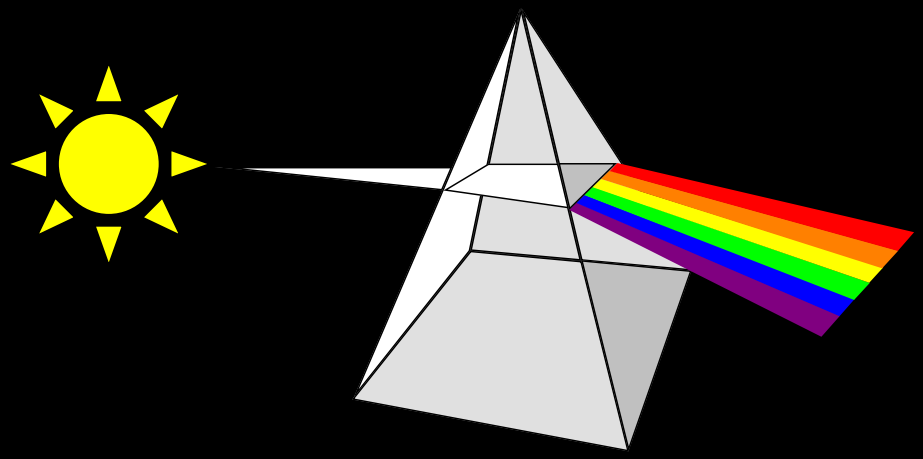
question for you

Star A and star B have the same luminosity. If star A is 2 times cooler than star B, how do their sizes compare?

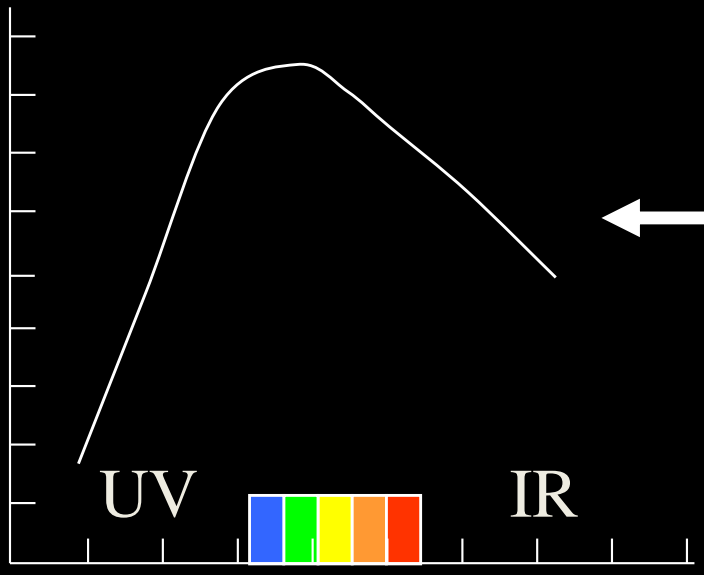
A. There is not enough information to infer this; we would also need to know their distances.
B. Star B has 2 times larger surface area than star A.
C. Star A has 16 times larger surface area than star B.
D. Their sizes are the same, if their luminosities are the same.
E. I have no idea.

If I know the luminosity, can I determine the temperature?

If I know the color, can I determine the temperature?



blue	460 nm	81
green	530 nm	85
yellow	580 nm	83
orange	610 nm	78
red	660 nm	70



Blackbody Curve - a graph of an object's energy output per wavelength.

The **peak** of this curve tells us about the object's temperature and color.

Color - when the lights are off!

Wein's law:

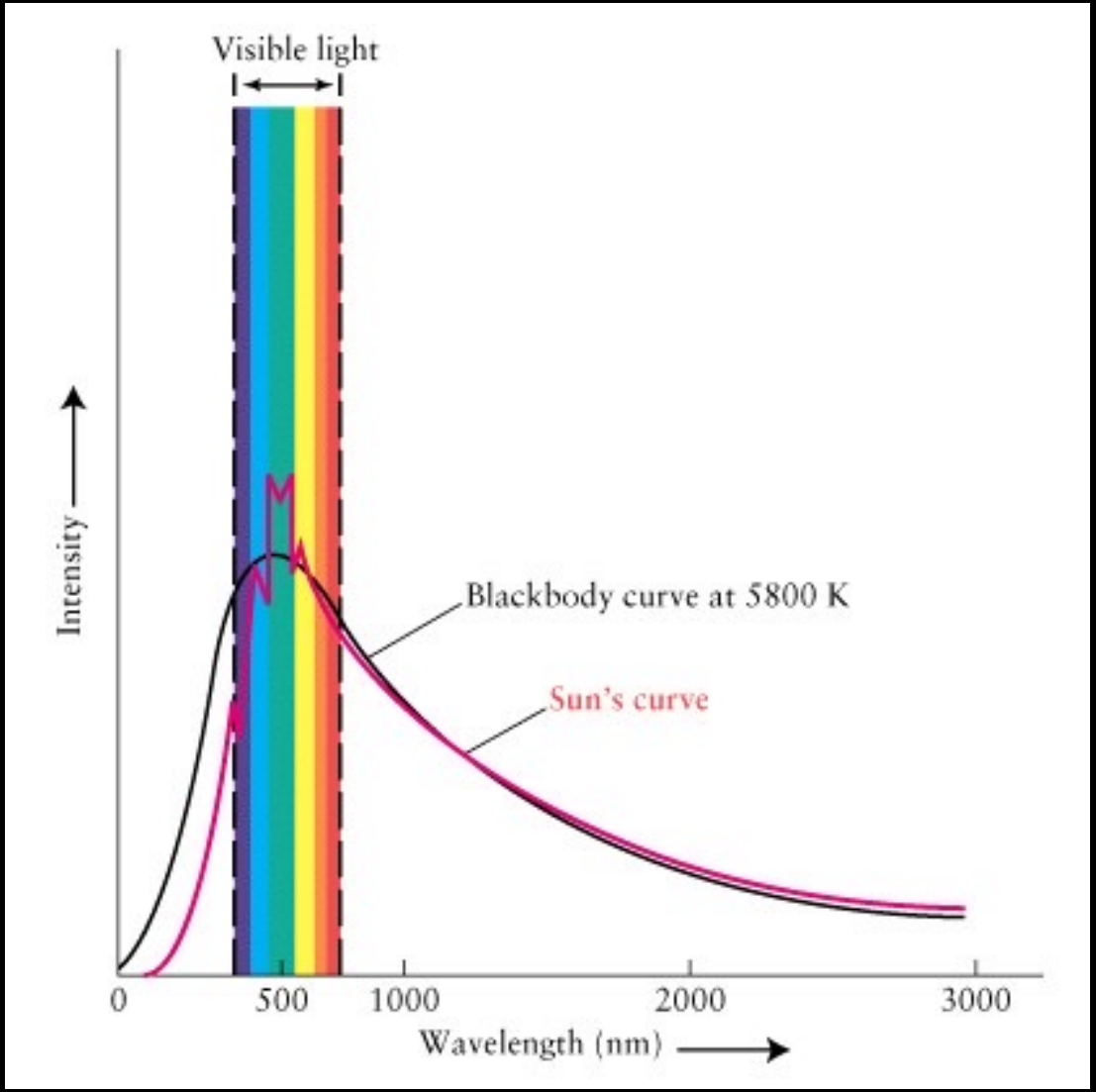
Relates the temperature of an object to the wavelength of the peak in the black body curve:

$\lambda_{peak} = (2.9 \times 10^{-3}) / T_{kelvin}$

- Hotter objects have shorter peak wavelength.

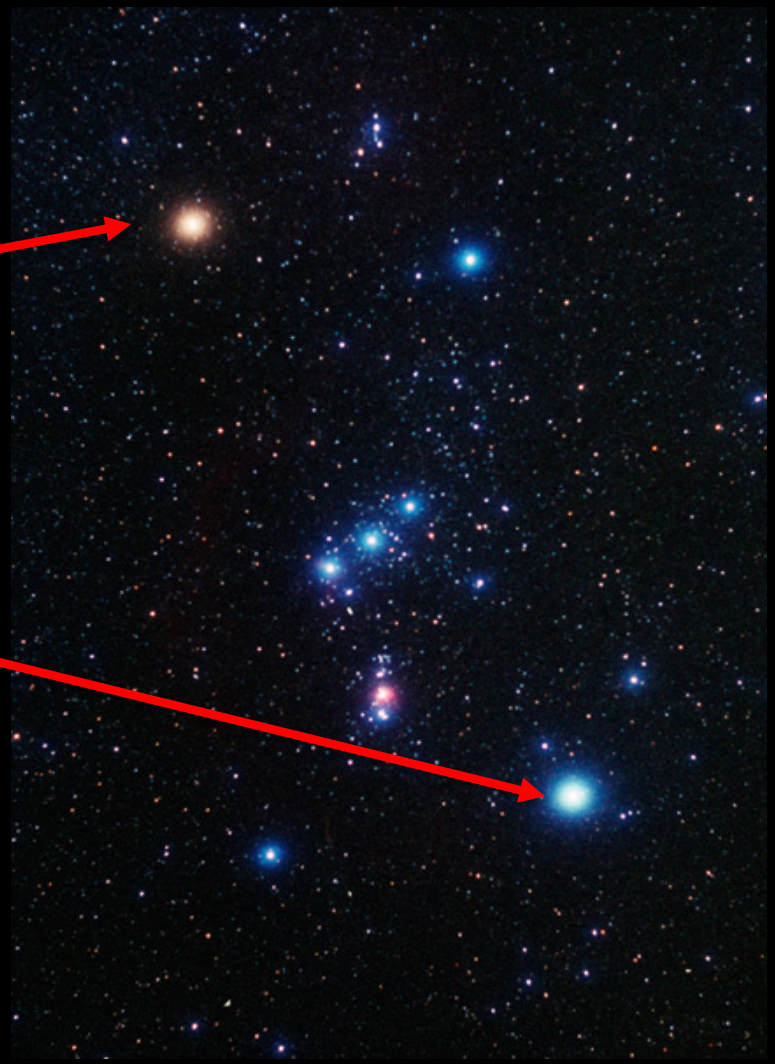
What color is our 5800 K Sun?

The Sun emits all wavelengths but most intensely in green/yellow part of the spectrum.



Which stars are hotter?

- The surface of Betelgeuse is 5840 °F (3500 K), so it radiates light peaked at red.
- Rigel has a surface temperature of 19,000 °F (11,000 K) and radiates most light in blue.



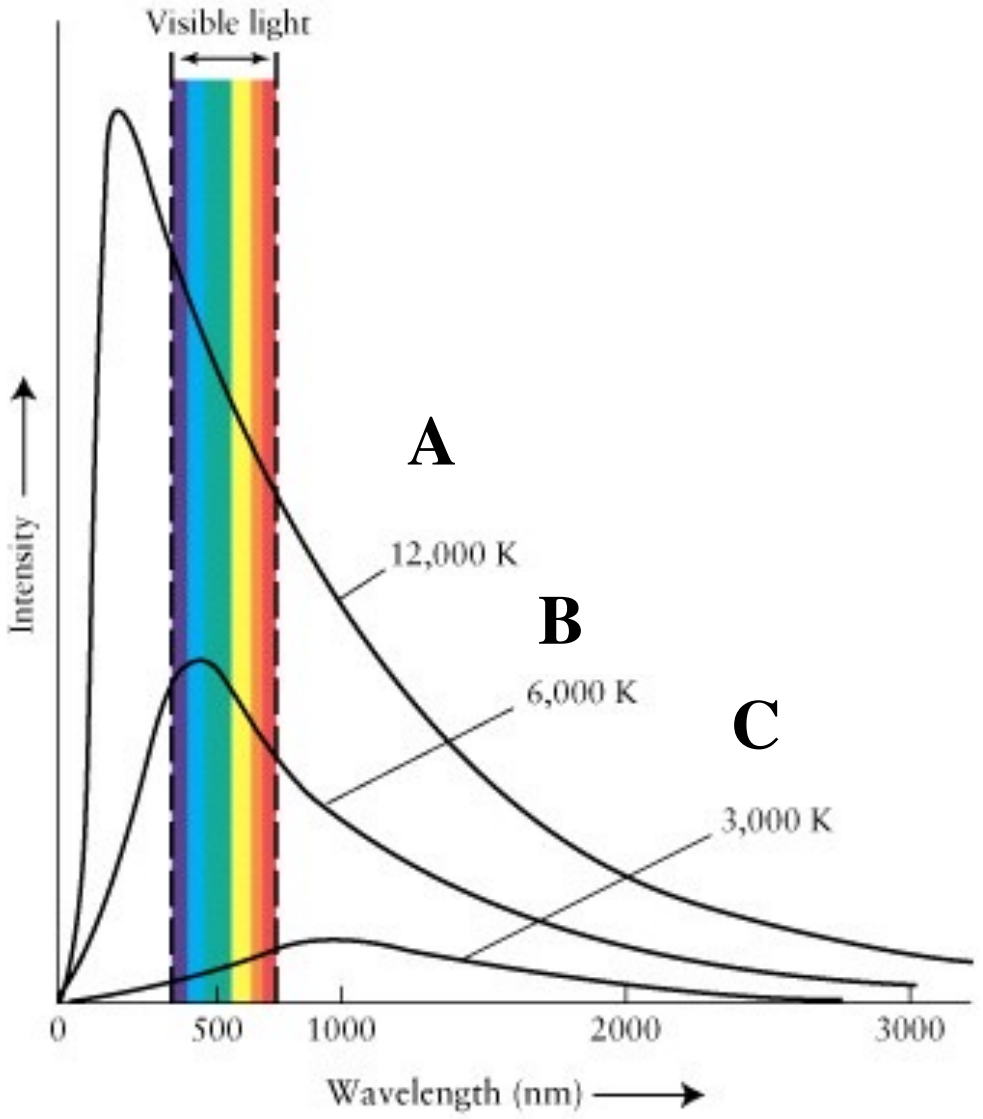
question for you

1. Which object gives off the greatest amount of blue light?

2. Which object gives off the greatest amount of red light?

3. Which object would appear red?

4. Which object would have the lowest temperature?



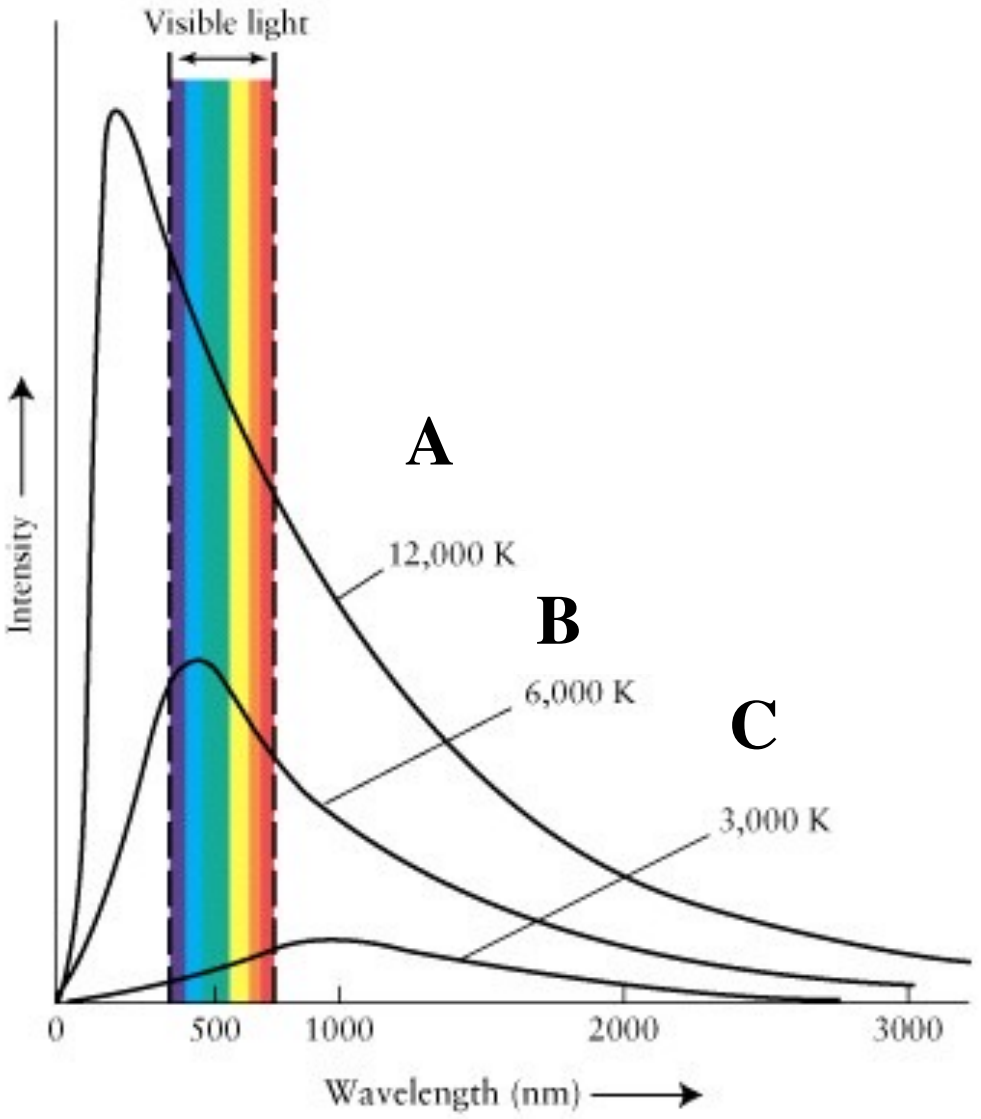
question for you

A 1. Which object gives off the greatest amount of blue light?

A 2. Which object gives off the greatest amount of red light?

C 3. Which object would appear red?

C 4. Which object would have the lowest temperature?



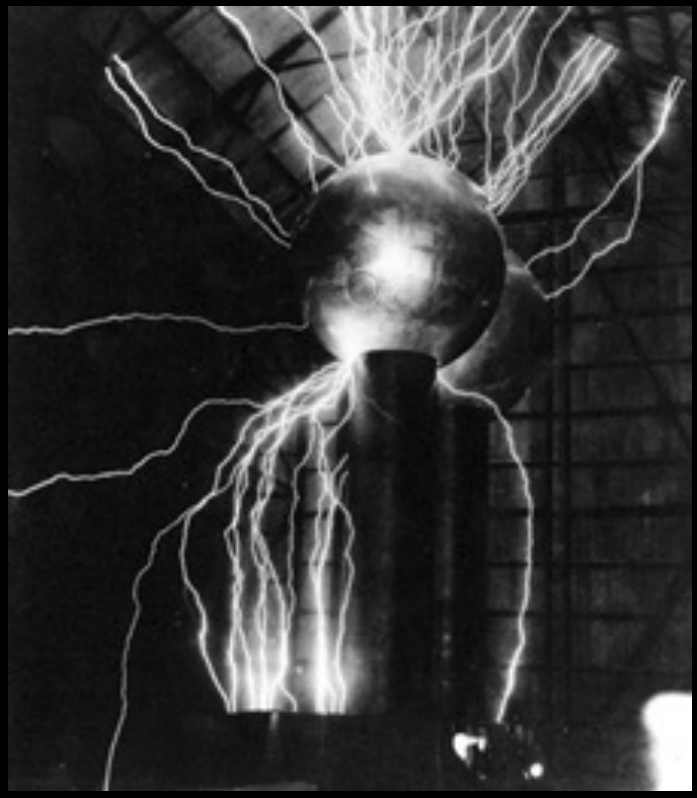
What can we learn from starlight?

1. Temperature
2. Composition

Atoms

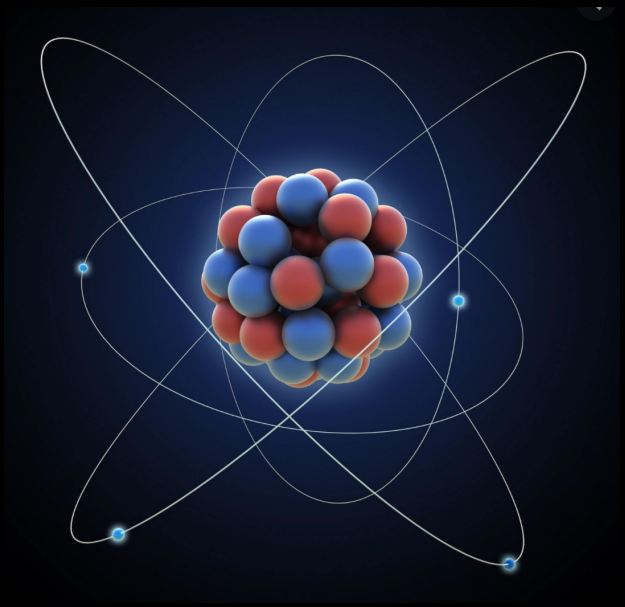
Electrons, protons, neutrons

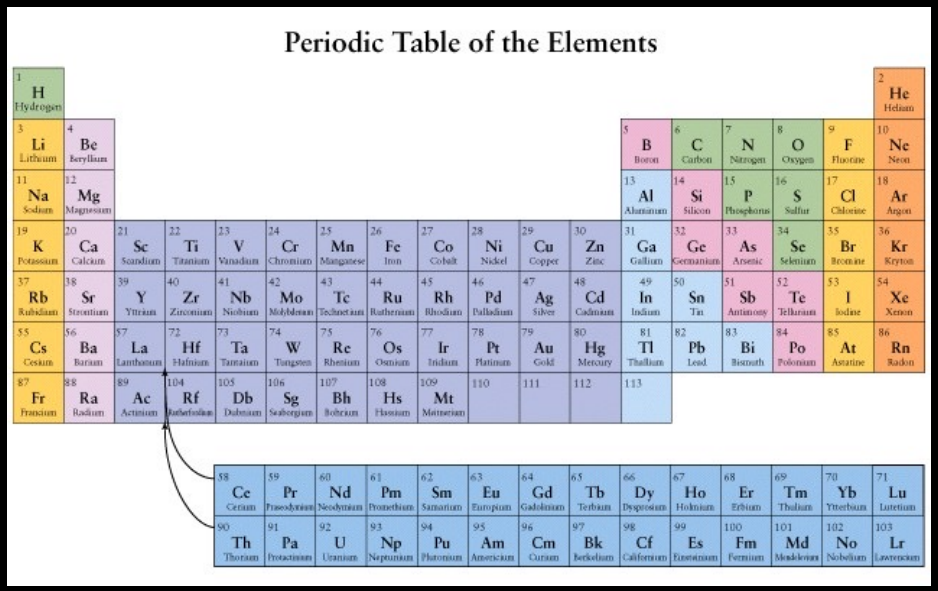
- Proton carry positive charge, electrons carry negative charge, and neutrons are neutral.
- For an object to carry a charge, it must have an imbalance of protons and electrons.
- Charges create electromagnetic radiation – light.



Atoms

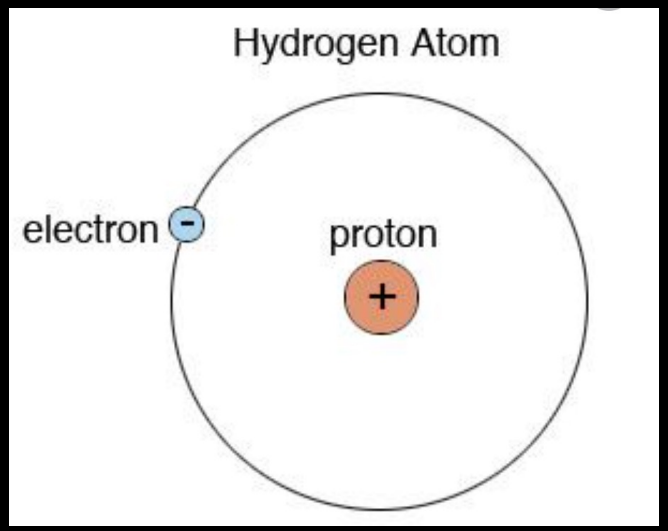
- ✓ Matter is made up of **atoms**.
- ✓ Each **element** has a unique atom that is a combination of neutrons and protons in the **nucleus**, surrounded by a cloud of **electrons**.
- ✓ A nucleus is about 10^{-15} m in size and the first electron orbits out at 10^{-10} m from the center of the atom.

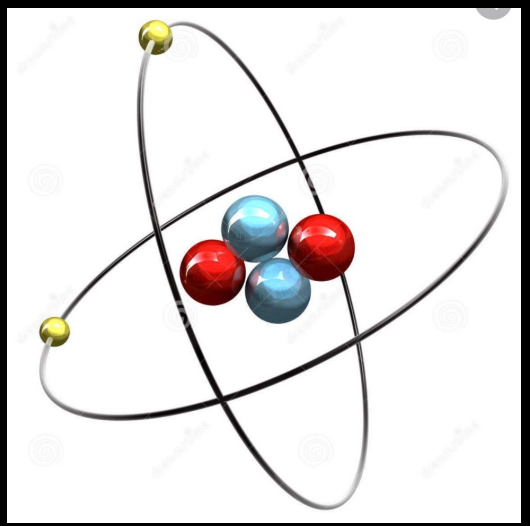


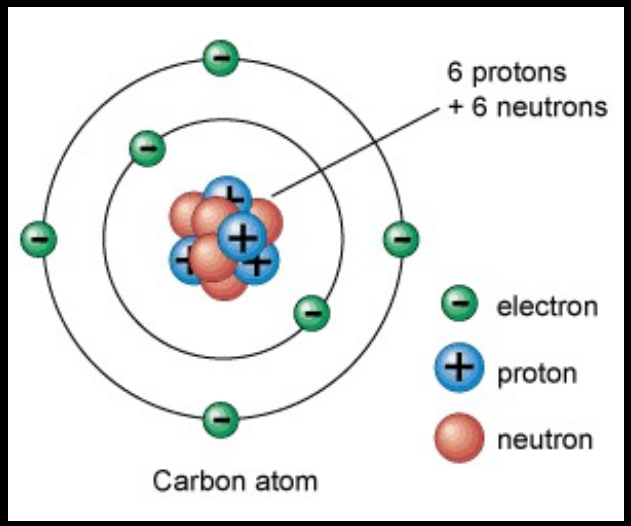


Atoms

- **Atomic number**=number of protons.
- **Mass number**=total number of nucleons.
- Hydrogen atom: one proton + one electron = the most common element in the Universe!
- Helium atom: two protons, two neutrons, two electrons.
- Carbon Atom: six protons, six neutrons, six electrons.

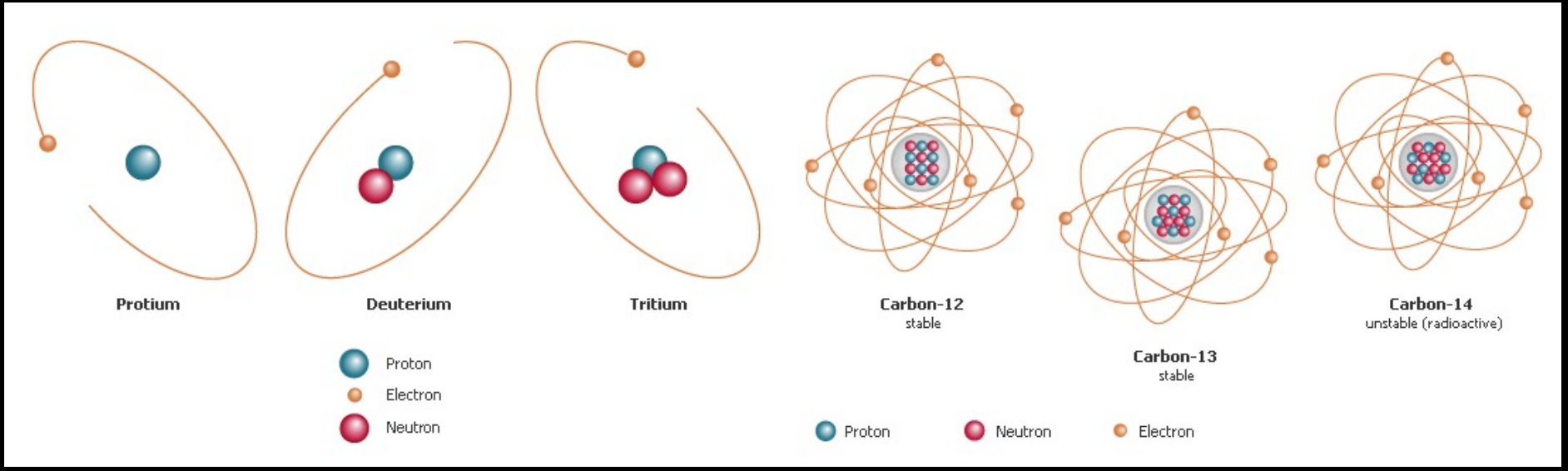






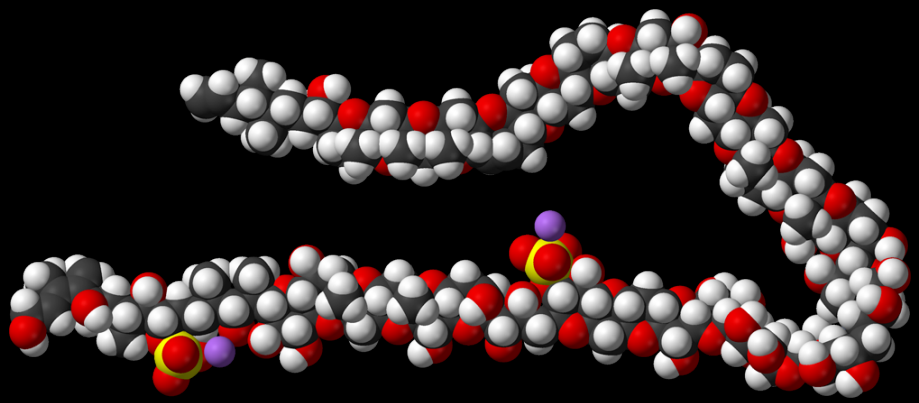
Isotopes

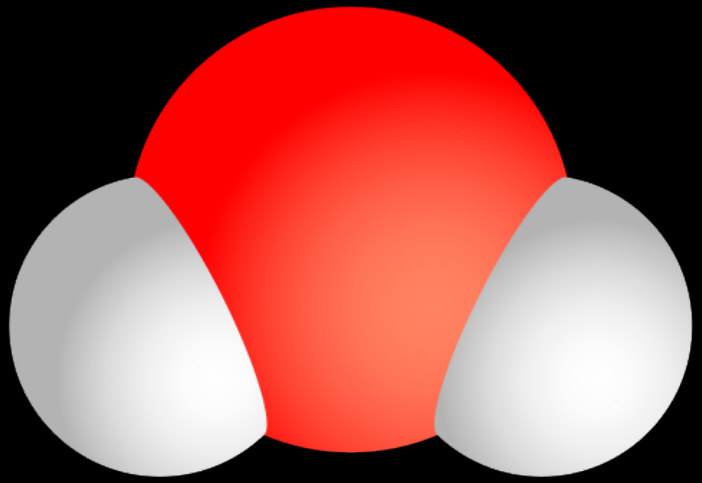
- Atoms of same element with extra neutrons.
- Adding a neutron to hydrogen atom gives **deuterium**. Adding two gives **tritium**.
- Carbon has three natural isotopes, one of which is unstable (and very important in determining age of fossils).



Molecules

- When two or more atoms bond together, a **molecule** is formed.
- One atom of oxygen plus two atoms of hydrogen give a molecule of **water**.
- **Organic molecules** contain C and H and are often complex chains of atoms.

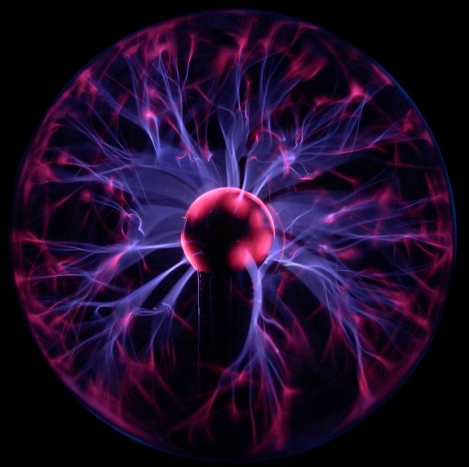




The Phases of Matter

- Solid: structural rigidity and resistance to deformation.
- Liquid: fluid whose shape is determined by container it fills.
- Gas: a collection of atoms and/or molecules in random motion, without a definite shape and volume.
- Plasma: **ionized gas** in which some or all of the electrons aren't bound to atoms.



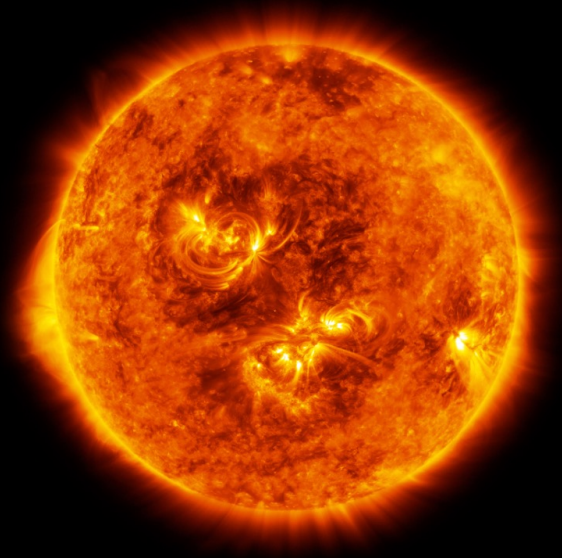



What's the most common state of matter in the universe?

Plasma!

Composition of the Universe

75% H + ~25% He (most of it produced in the Big Bang) + trace of heavier elements (most of it produced in stars).



question for you

What's most common in space?

A. Free protons and electrons
B. Atomic nuclei from the whole periodic system and free electrons
C. Organic molecules
D. Atomic nuclei containing one proton and one neutron
E. I have no idea.

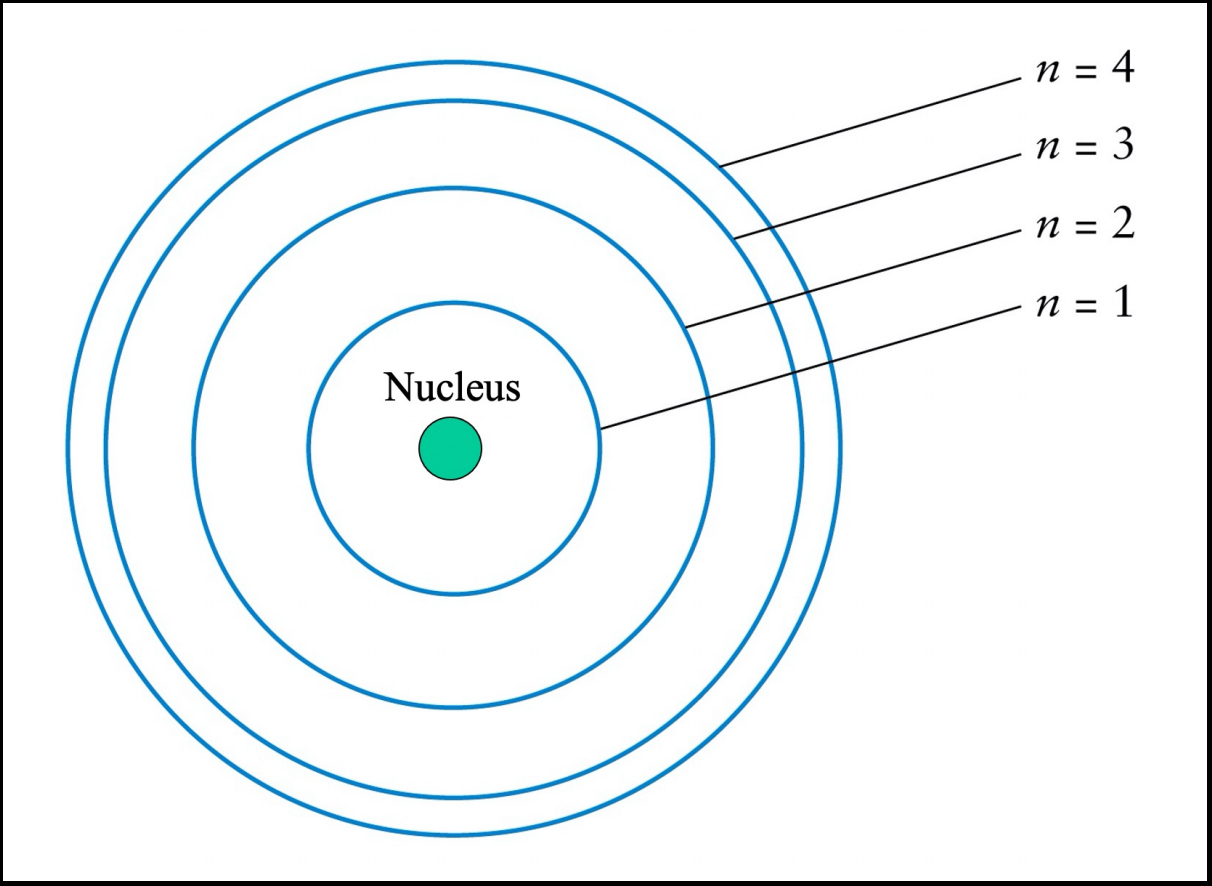
question for you

What's most common in space?

A. Free protons and electrons
B. Atomic nuclei from the whole periodic system and free electrons
C. Organic molecules
D. Atomic nuclei containing one proton and one neutron
E. I have no idea.

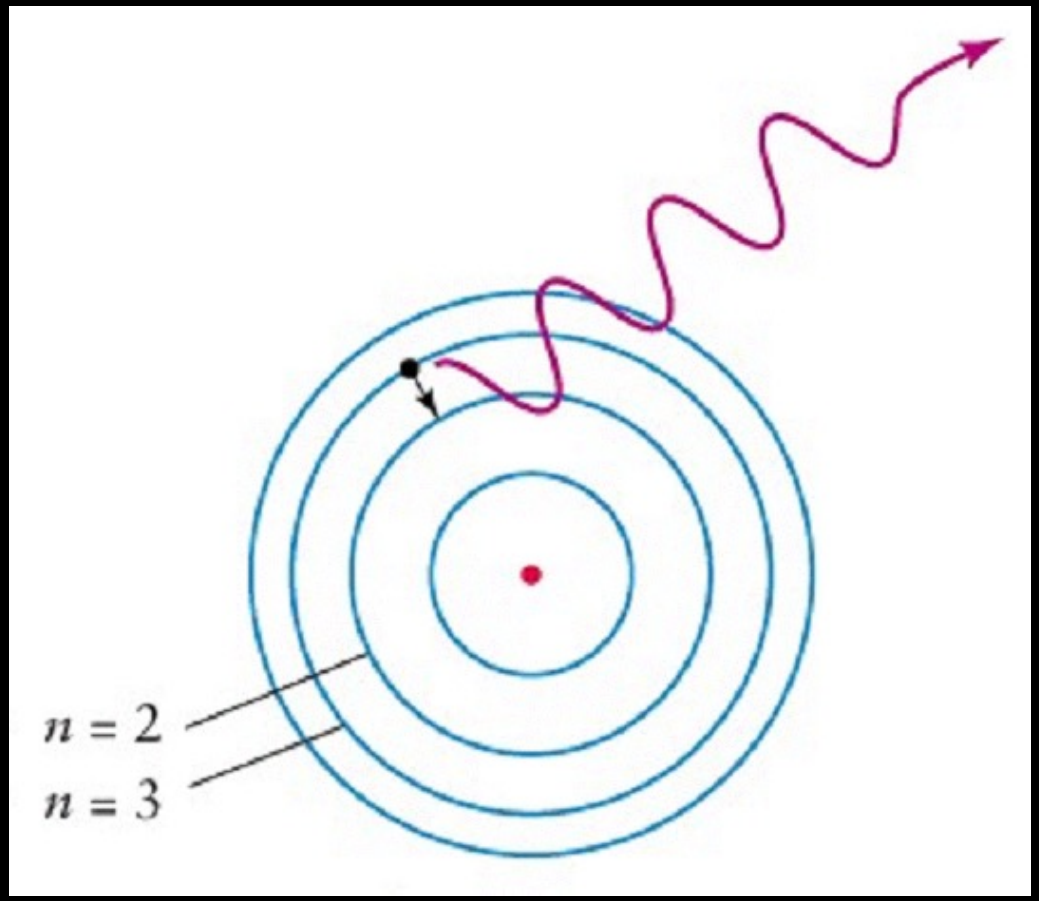
Back to atoms

Atomic energy levels



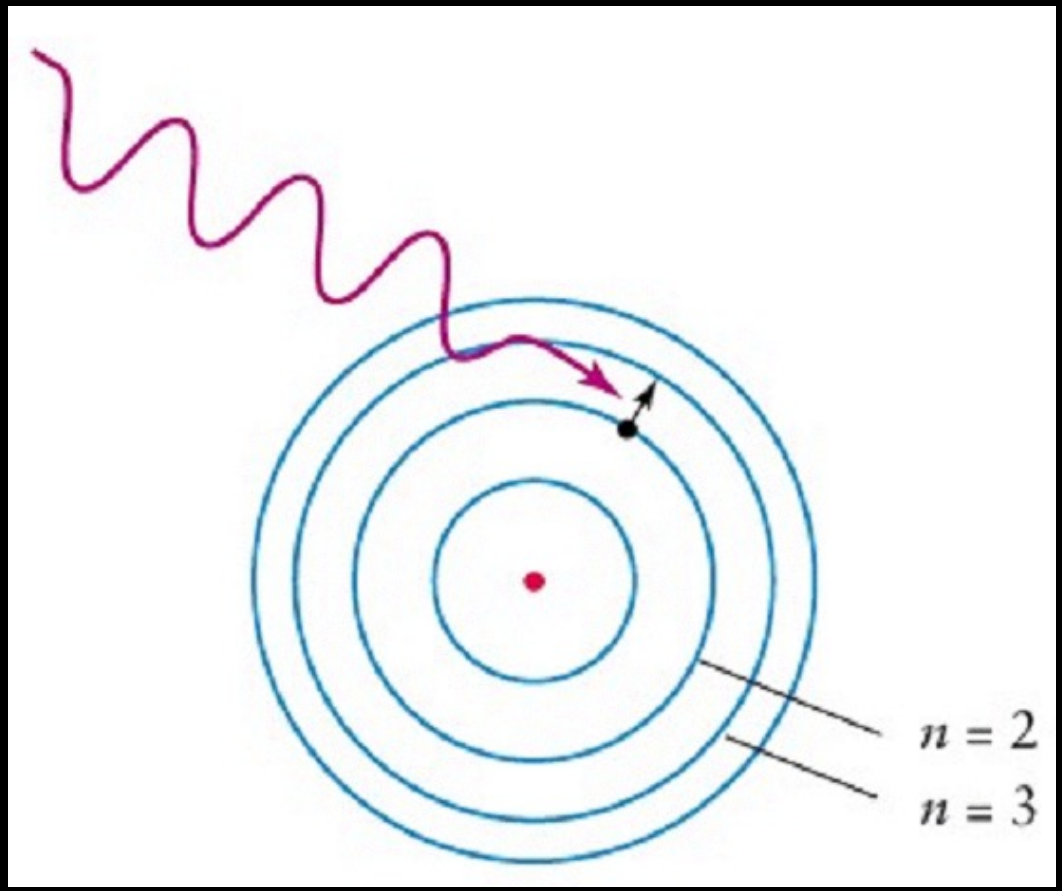
Emission of a photon

Photon is emitted from an atom when an electron moves from a higher energy level to a lower energy level.



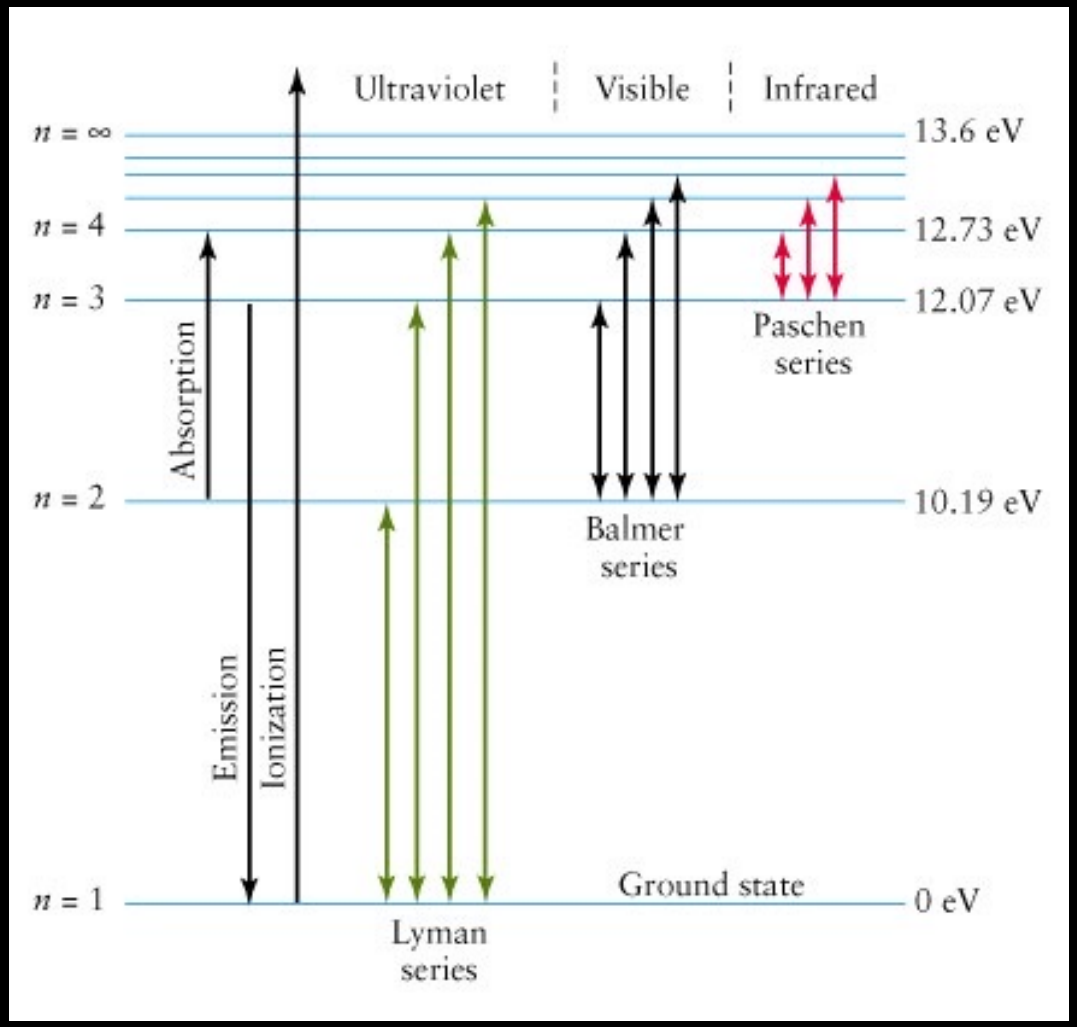
Absorption of a photon

When a photons is absorbed by an atom, its electron moves from a lower energy level to a higher energy level.



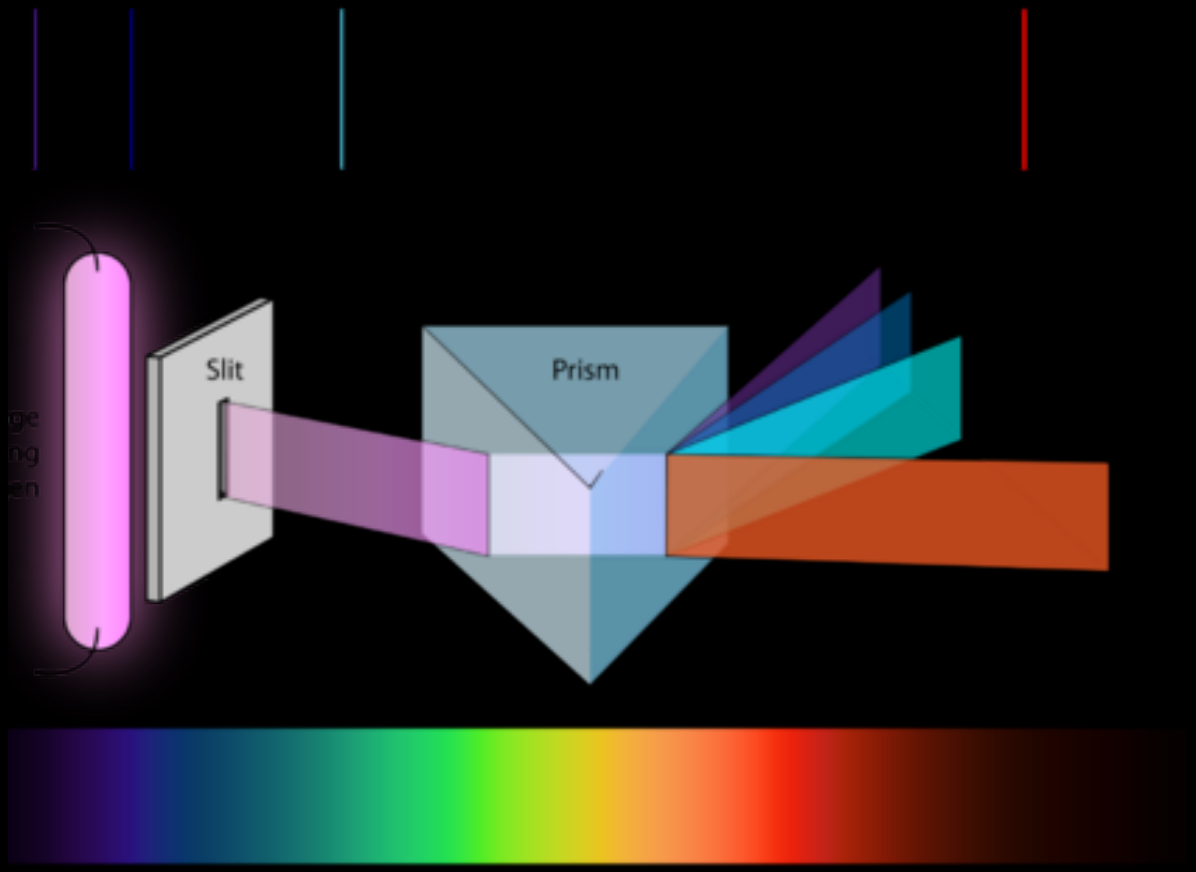
Atomic energy levels

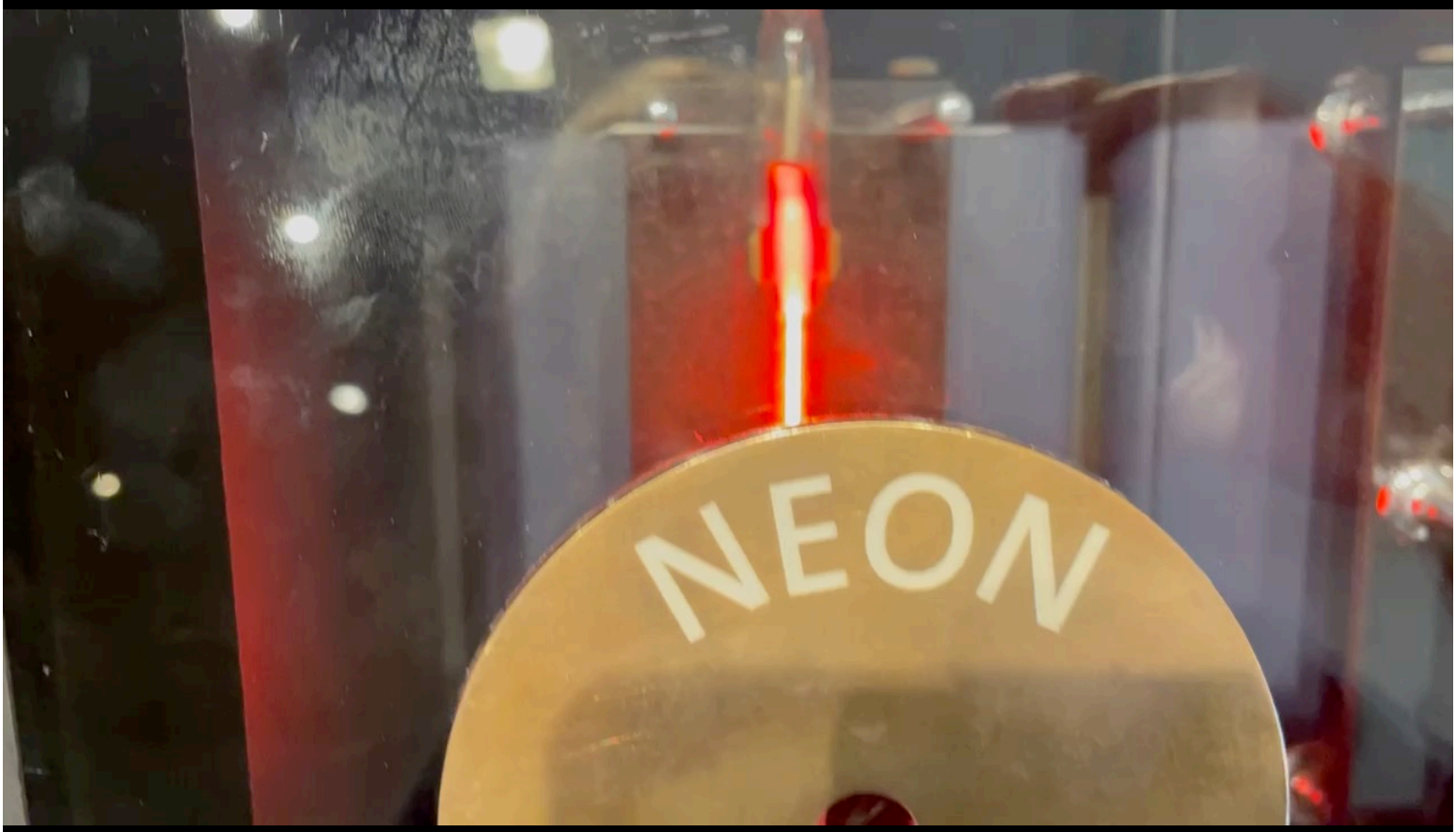
Structure of atomic levels determines which energies of photons are possible for the atom to absorb or emit.



Atomic “fingerprints”

Each chemical element produces its own unique set of spectral lines when it is excited!



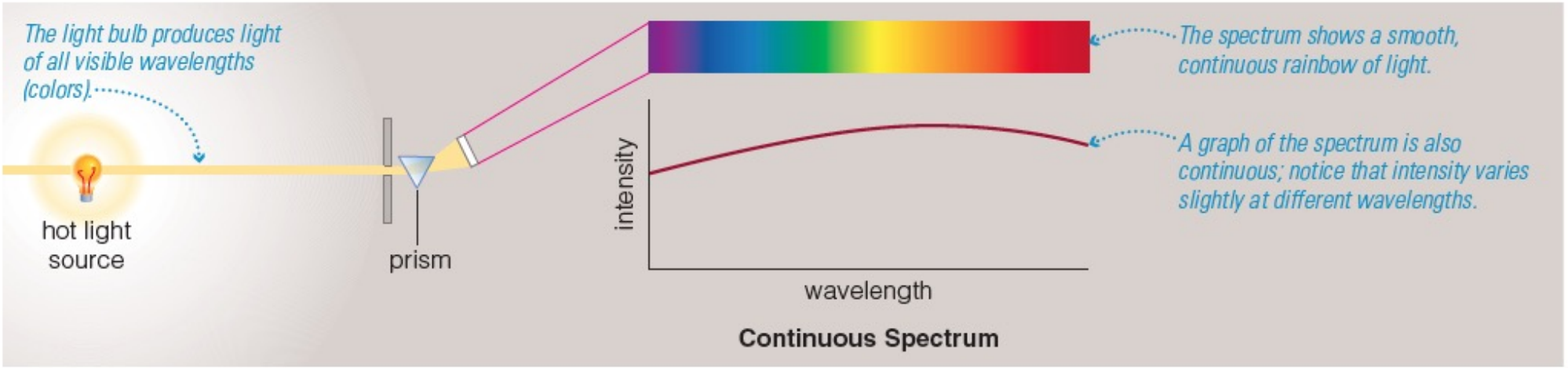

NEON

Hydrogen gas spectrum: which line below corresponds to the “biggest jump” in atomic energy levels?

Three types of spectra

Continuous Spectrum

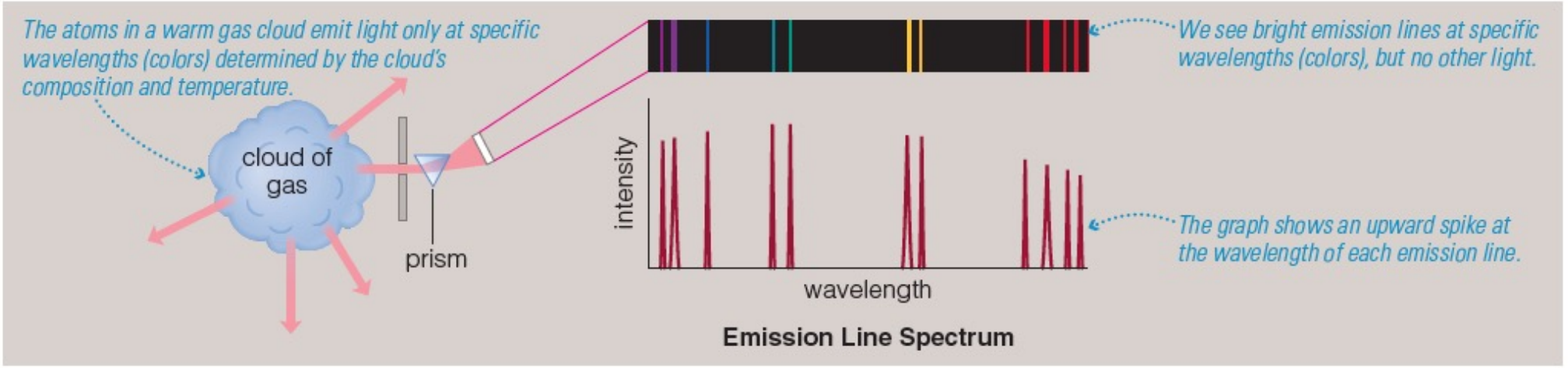
- Uninterrupted rainbow of wavelengths



Three types of spectra

Emission Spectrum

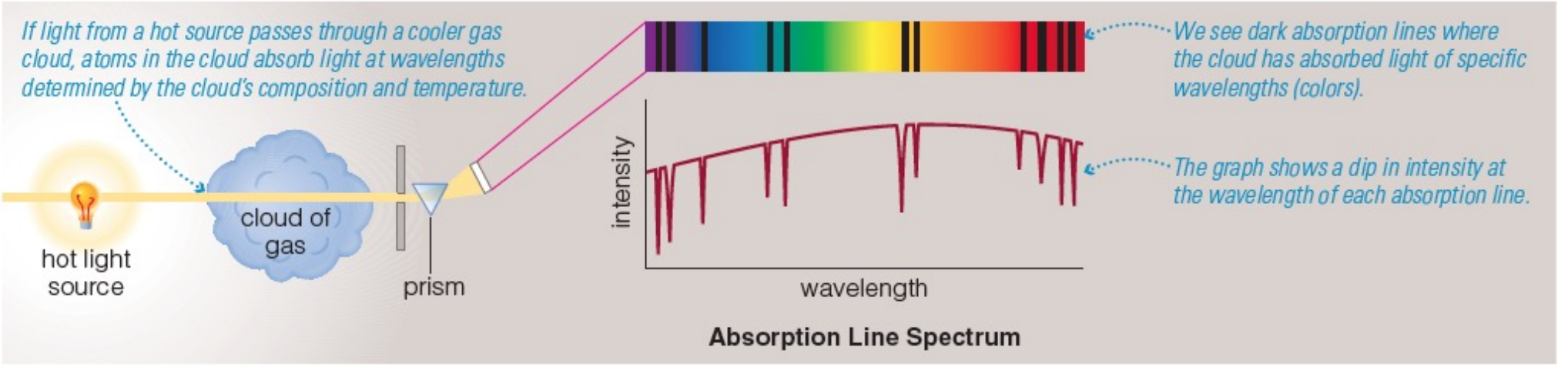
- Specific wavelengths emitted



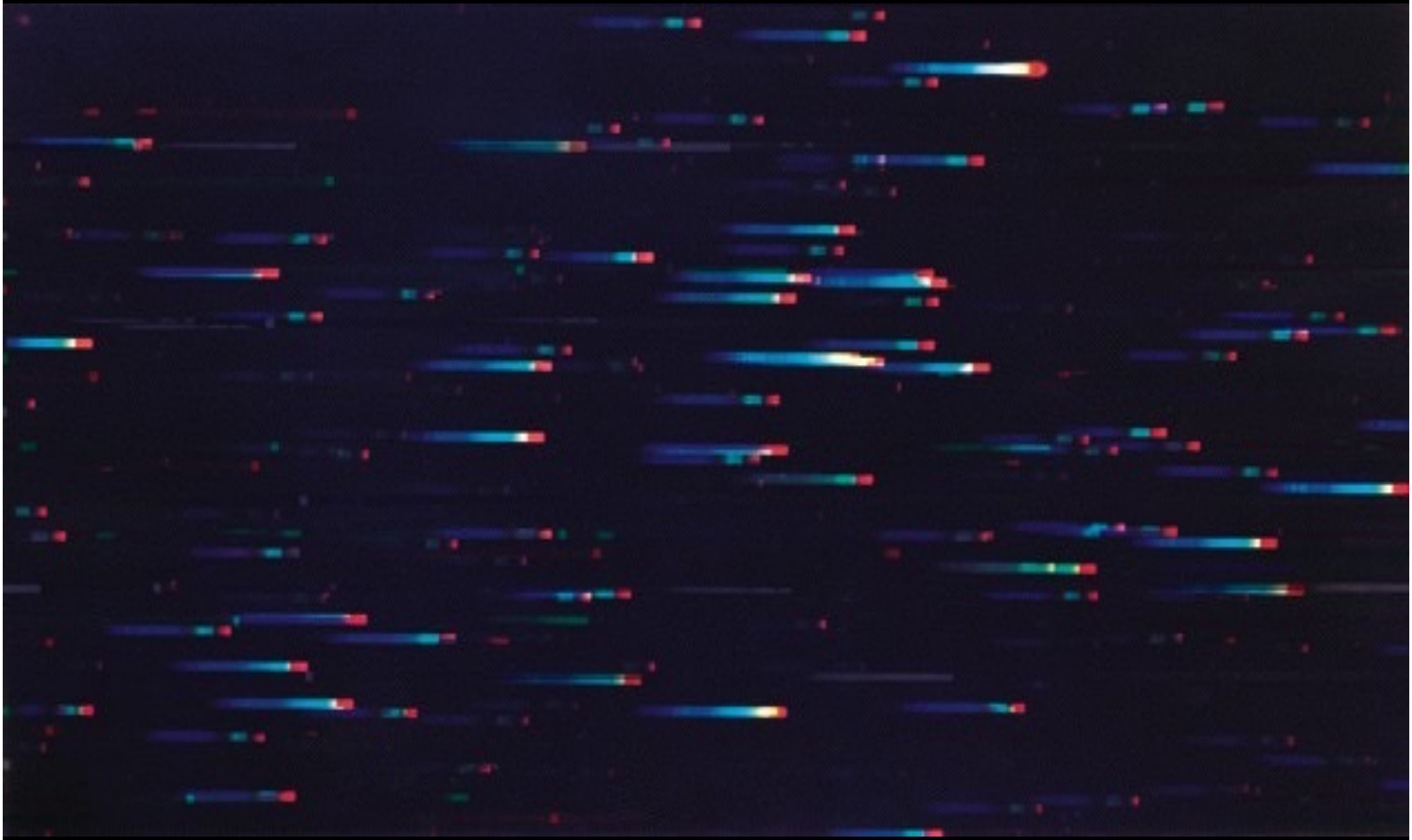
Three types of spectra

<u>Absorption Spectrum</u>

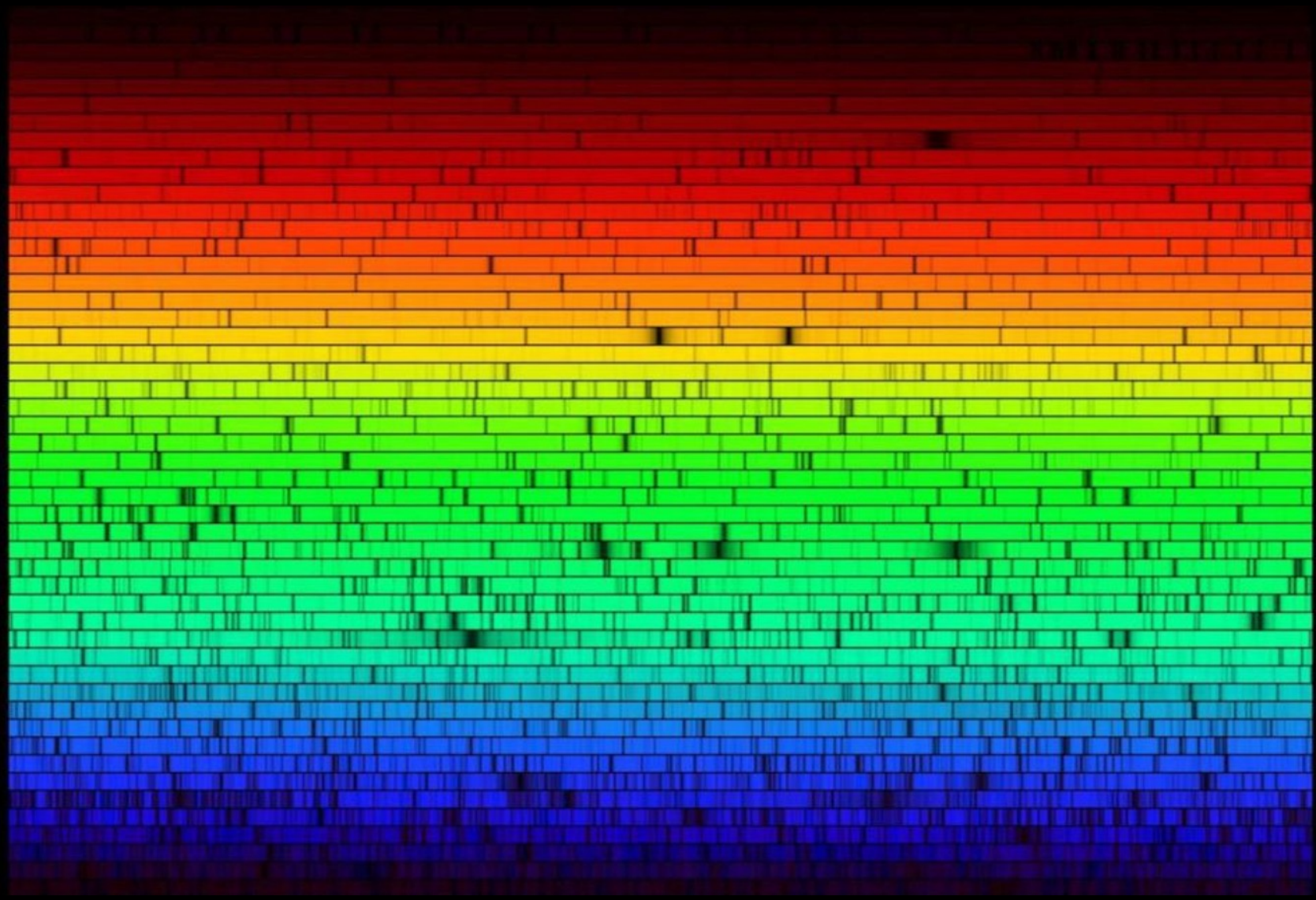
- "Missing" wavelengths tell us about the gas cloud.



Spectra of stars



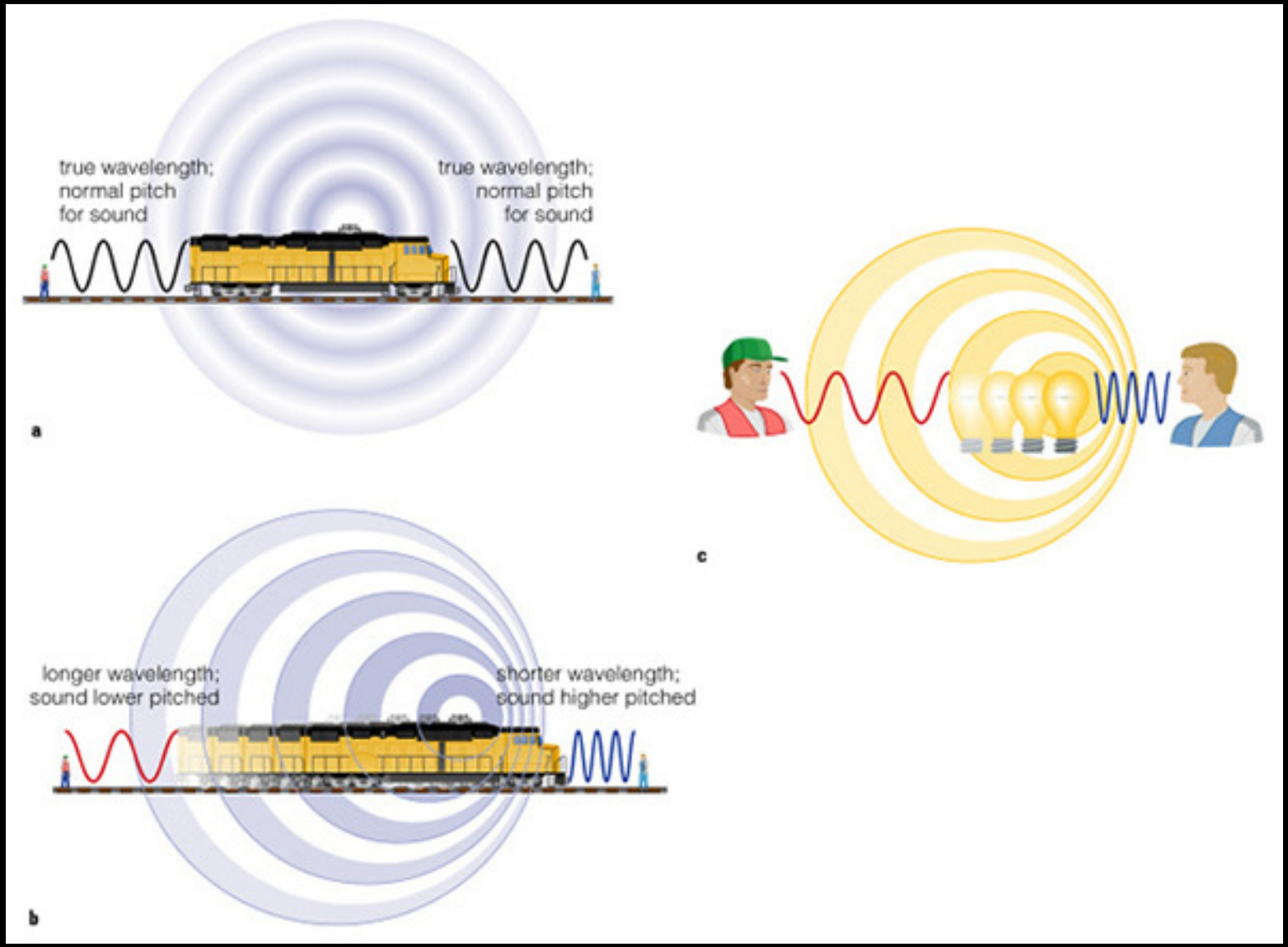
Spectrum of the Sun



Redshift

Doppler effect

Doppler effect

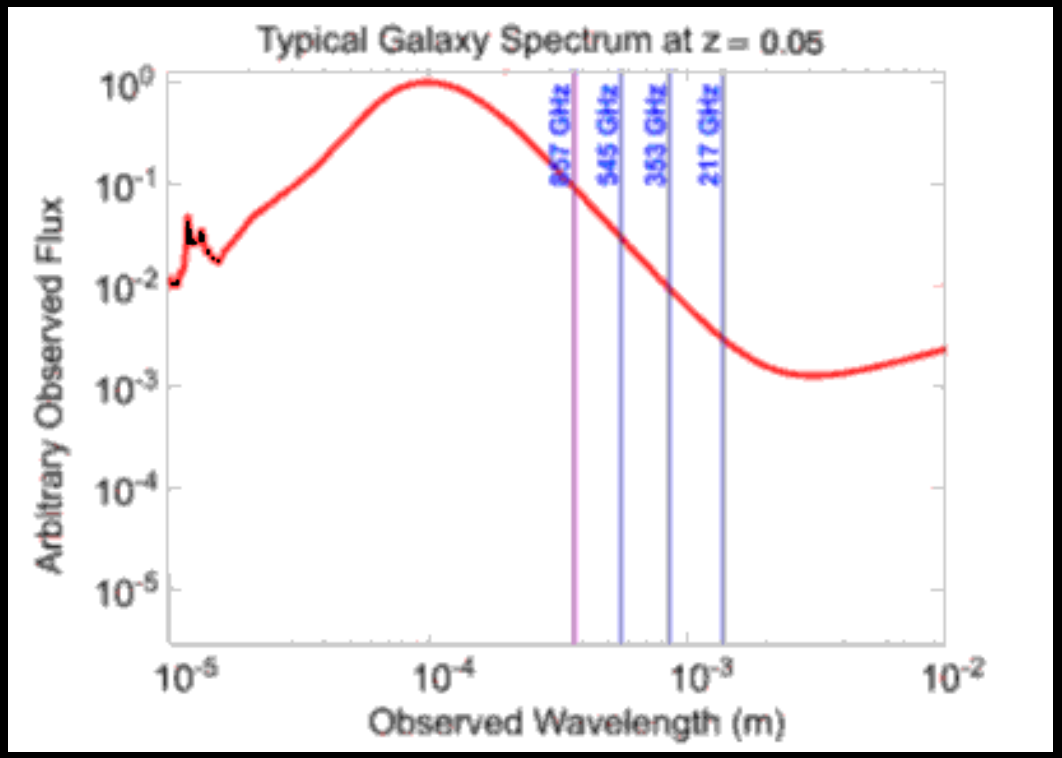


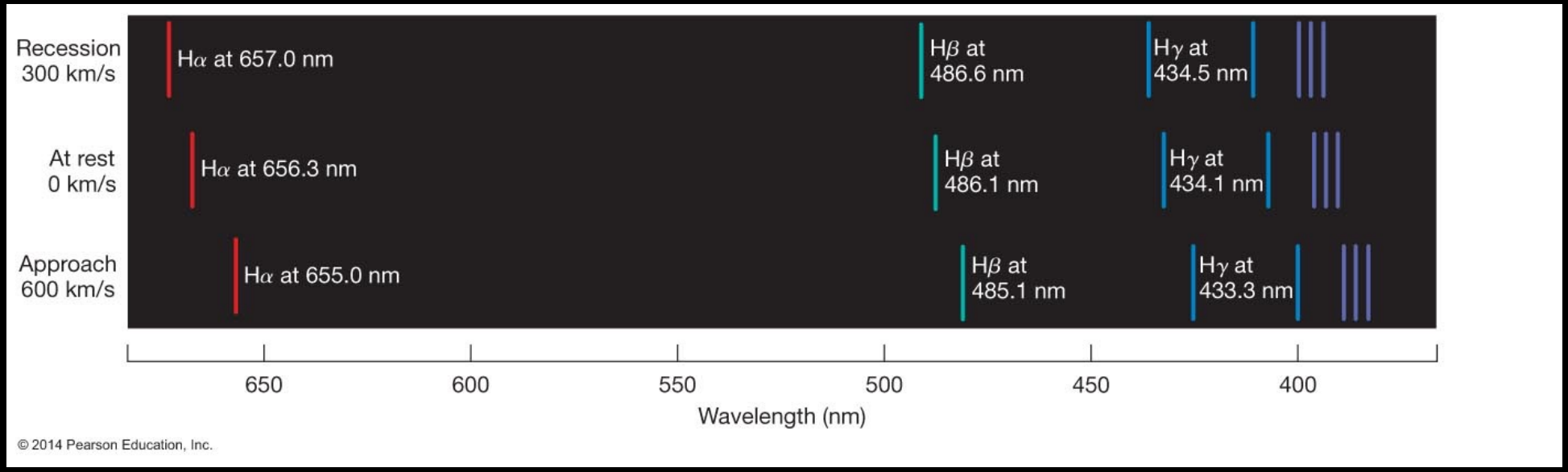
Shift is proportional to speed

- Objects moving away are **redshifted**, meaning the spectrum is moved toward the red colors.

- Objects moving toward us are **blueshifted**.

Redshift

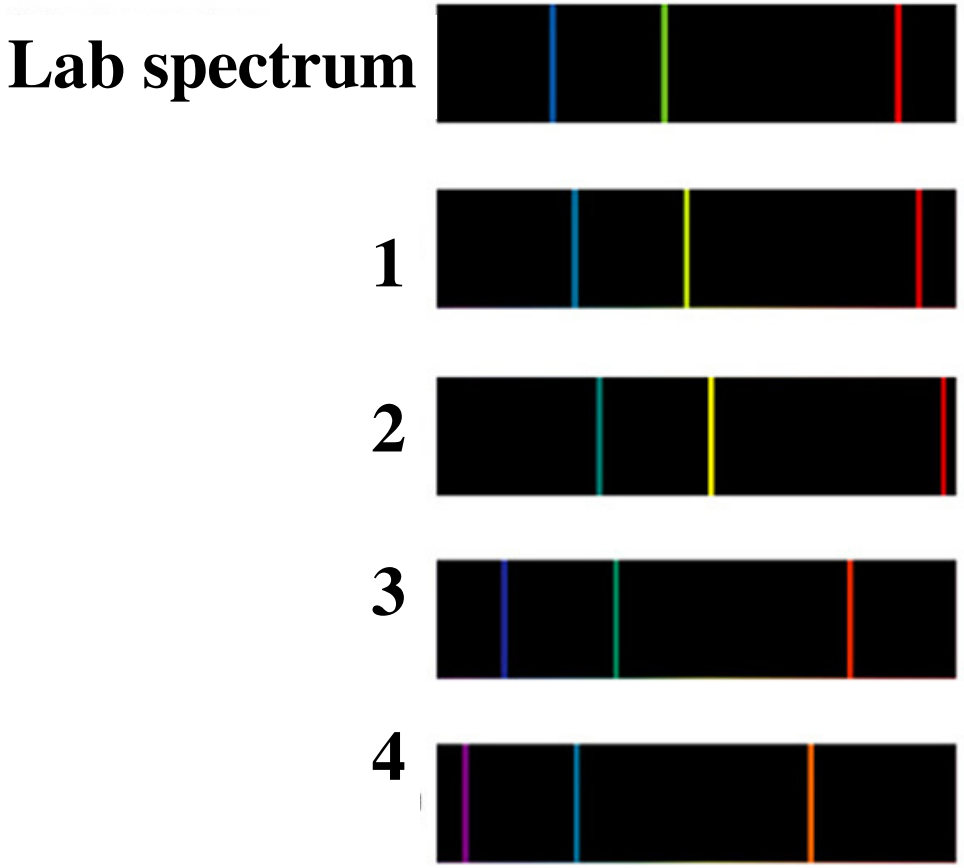




question for you

You observe the spectra shown below. Which object is moving fastest away from us?

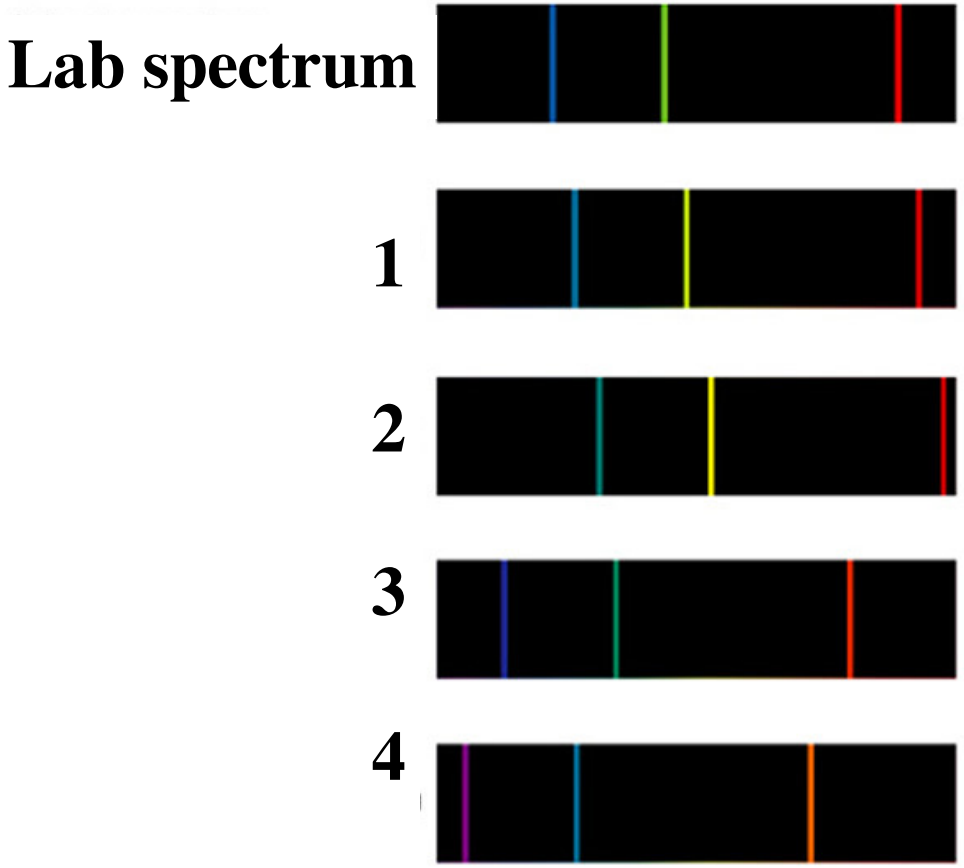
A. Object 1.
B. Object 2.
C. Object 3.
D. Object 4.
E. I have no idea.



question for you

You observe the spectra shown below. Which object is moving fastest away from us?

A. Object 1.
B. Object 2.
C. Object 3.
D. Object 4.
E. I have no idea.



What can we learn by analyzing starlight?

1. Temperature
2. Composition
3. Speed

Power of spectroscopy

Power of spectroscopy

ASTROBIOLOGY MAGAZINE

Search

Advanced Search

facebook twitter

HOME | NEWS | FEATURES | HOT TOPICS | MULTIMEDIA | new Hot Zone

NEWS EXCLUSIVES

Hot Topic ➡ Deep Space ➡ New Planets ➡ Atmosphere of an Extrasolar Planet Detected for the First Time

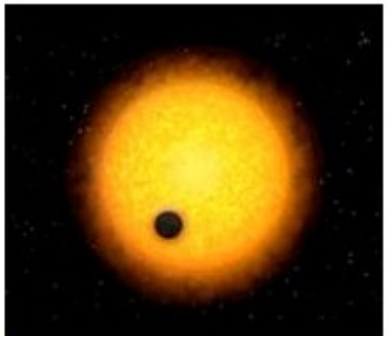
Atmosphere of an Extrasolar Planet Detected for the First Time

MY ASTRO

New Planets
Posted: 12/05/01
Author: Leslie Mullen

Summary: Astronomers have made the first direct detection and chemical analysis of an atmosphere of a planet that exists outside our solar system.

Atmosphere of an Extrasolar Planet Detected for the First Time



Astronomers have made the first direct detection and chemical analysis of an atmosphere of a planet that exists outside our solar system.

The planet HD 209458b - orbits a yellow, Sun-like star that lies 150 light-years away. The star HD 209458 is in the constellation Pegasus, and can be seen with an amateur telescope.

What did we learn in Chapter 7?

- Matter is made up of atoms, and each atom is comprised of positively charged protons and neutral neutrons in the nucleus, with a cloud of negatively charged electrons surrounding the nucleus.
- An isotope is a version of an atom with a different amount of neutrons in its nucleus.
- A molecule is a combination of two or more atoms.
- Plasma, the fourth state of matter, is unique in that it can conduct electricity since most or all of the electrons have been stripped from the atoms and are free to move around.

What did we learn in Chapter 7?

- Atomic spectra are unique to each atom and are caused by the transition of electrons to lower/higher energy states in that atom. Type of spectra are:
  - Absorption: cold gas absorbing characteristic wavelengths from light passing through.
  - Emission: hot gas emitting characteristic wavelengths of the gas.
  - Continuous: rainbow spectrum representing light given off by a hot object.
- Hotter objects emit at shorter wavelengths and also emit more light per surface area than colder objects.