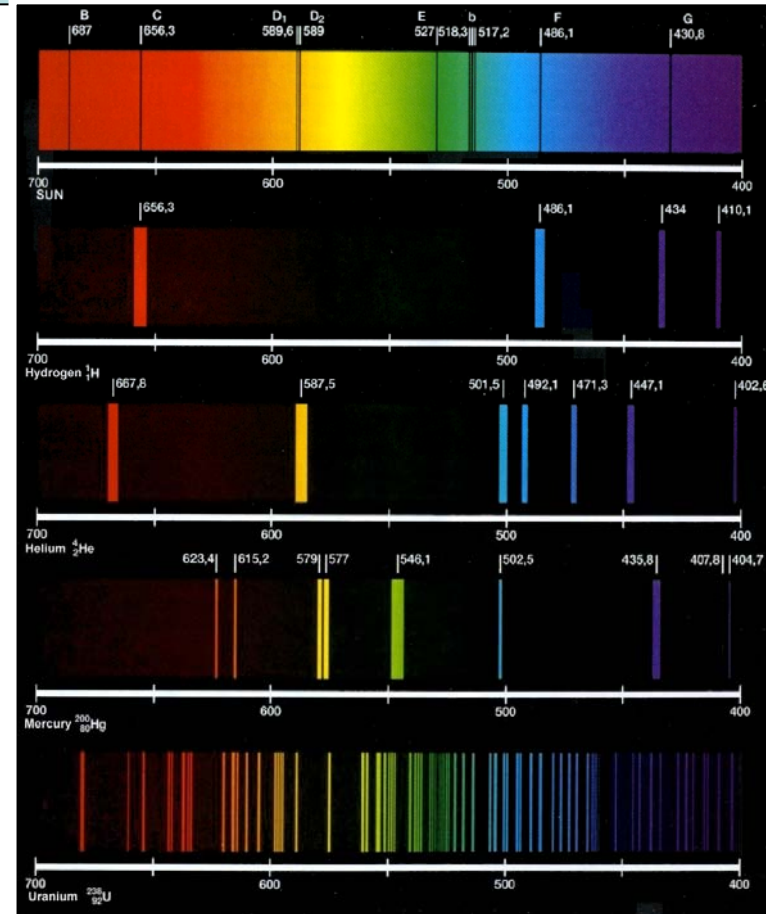


Atomic energy levels

Announcements:

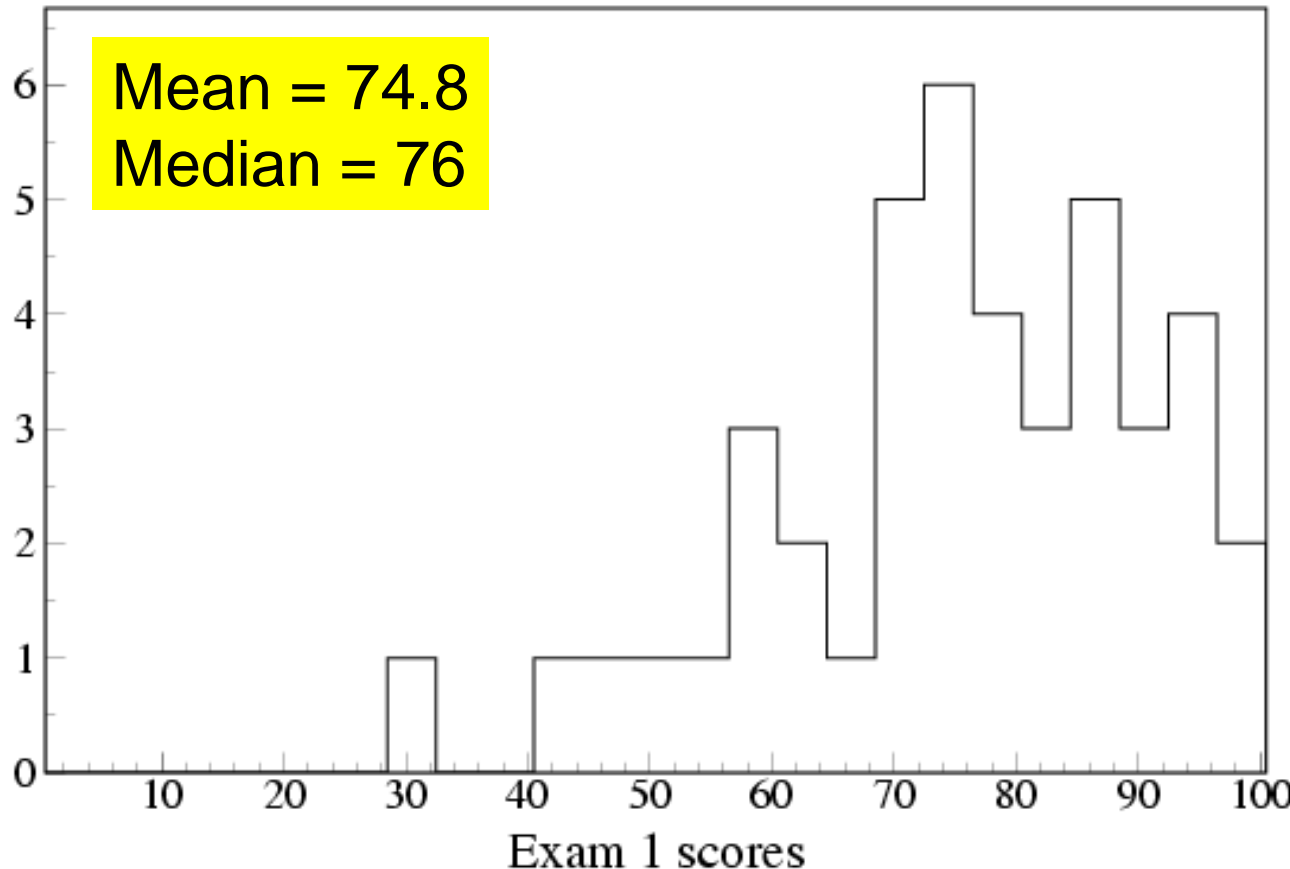
- Next weeks homework is available (7 problems but not too difficult – I hope).
- Exam solutions and homework 5 solutions are posted.
- Problem solving sessions are M3-5 and T3-5.



Exam 1 results

In my opinion it was a tough test and most of you did quite well on it. No 100's but there were two 97's.

One way to consider the extra credit is as an addition to your exam score. Based on the way the percentages work out, you can take your HW5 score, divide by 4 and add to your exam 1 score.



A few comments on the relativity problem

The first two relativity problems asked about the Batmobile dimensions and which lights came on first in the rest frame.

Some responses implied that it was only an observational effect.

The length of the car just ***appeared*** contracted to Robin.

The order of the lights coming on depends on where the Batmobile is with respect to Robin

These statements are not correct.

The moving Batmobile ***is*** shorter. In fact, we had a HW problem that showed it might even ***appear*** to be longer but once you set up the observers and account for the speed of light you find it ***really is*** shorter.

The rear lights ***do*** come on first in the rest frame. If Robin is in front of the Batmobile he will see the front lights come on first but once he accounts for everything he will realize the rear ones turned on first.

Back to thinking about the atom

To “see” an object you need to bounce something off the object.

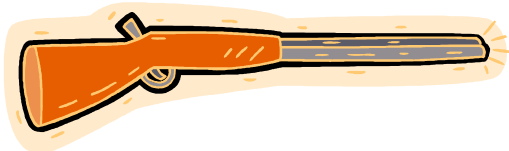
When you use your eyes, you are using the photons which are bounced off of the object to “see” it.

Depending on the object and the type of photons, the photons may go through (transparent) or reflect (opaque).

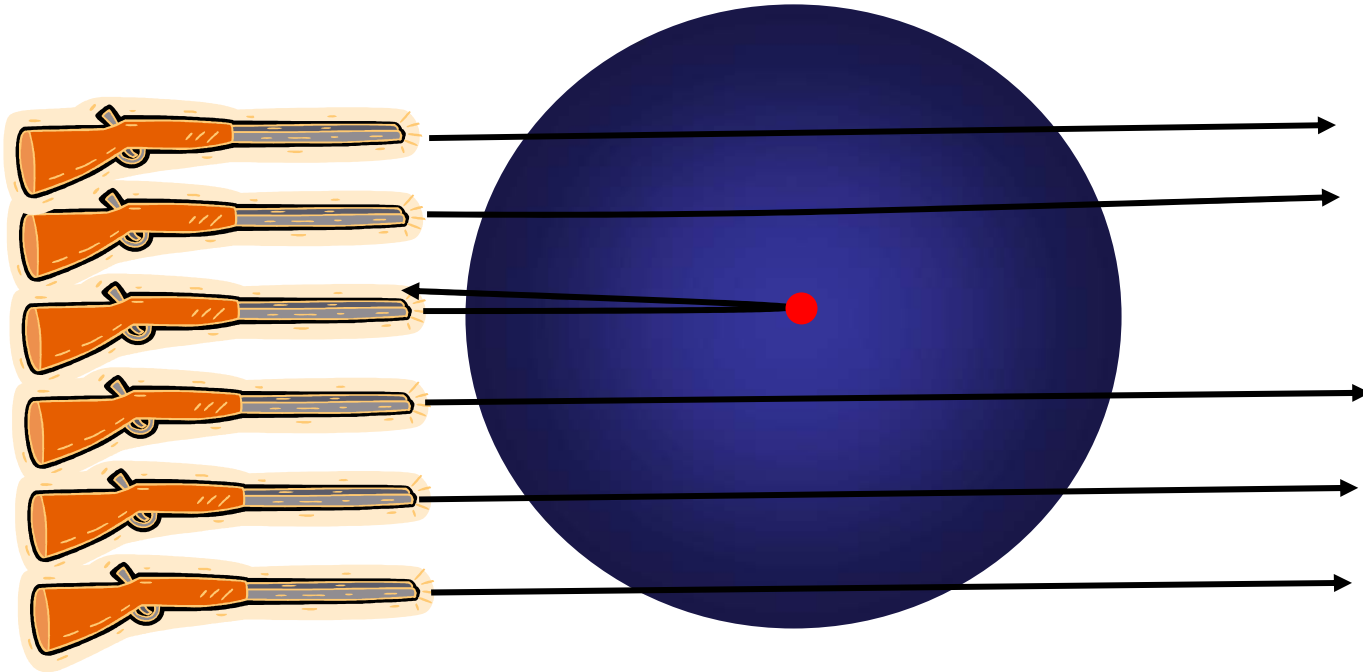
For instance, if you send energetic photons (X-rays) into a body, the photons mostly go through soft tissue and reflect off the bone.

We are going to do this with the atom but we will be hitting it with a variety of probes (photons, electrons, and alpha particles)

γ , e, and α gun



Rutherford scattering of alpha particles off nucleus



Rutherford used alpha particles (He nuclei) to probe the atom.

Most of the atom was pretty transparent to the alpha particles.

Alpha particles that happened to go near the nucleus were scattered at large angles. Discovery of nucleus.

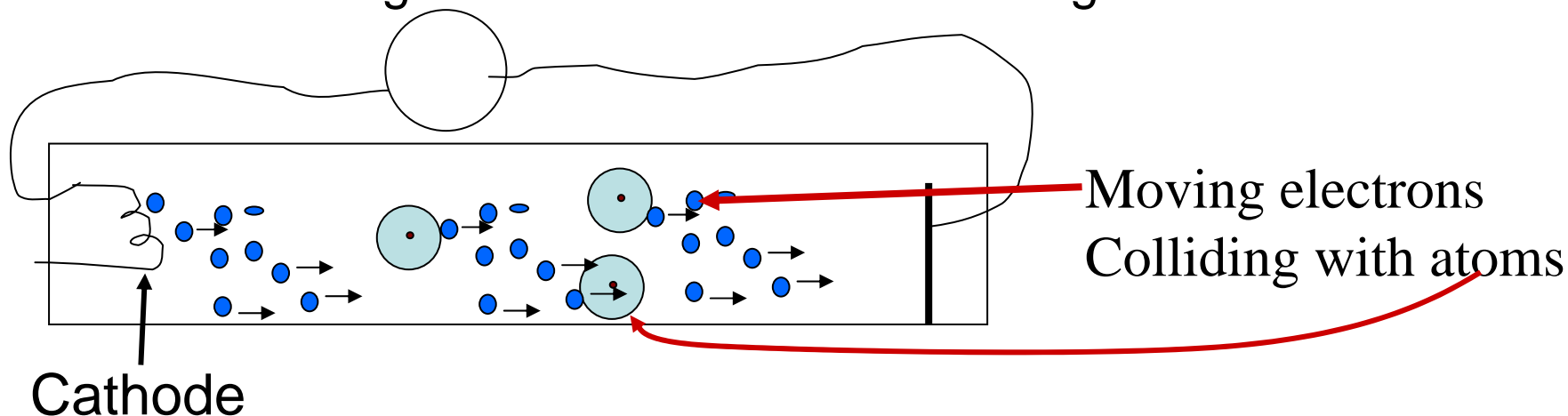
Shooting *electrons* at atoms

Atomic discharge lamps are a way of shooting electrons at an atom.

In atomic discharge lamps, lots of electrons given bunch of energy (voltage). Bash into atoms. (*Neon lights, Mercury street lamps, fluorescent lights*)

These free electrons excite the atomic electrons

120 Volts voltage difference or more with long tube



Viewing discharge lamps with diffraction grating

Using your diffraction grating

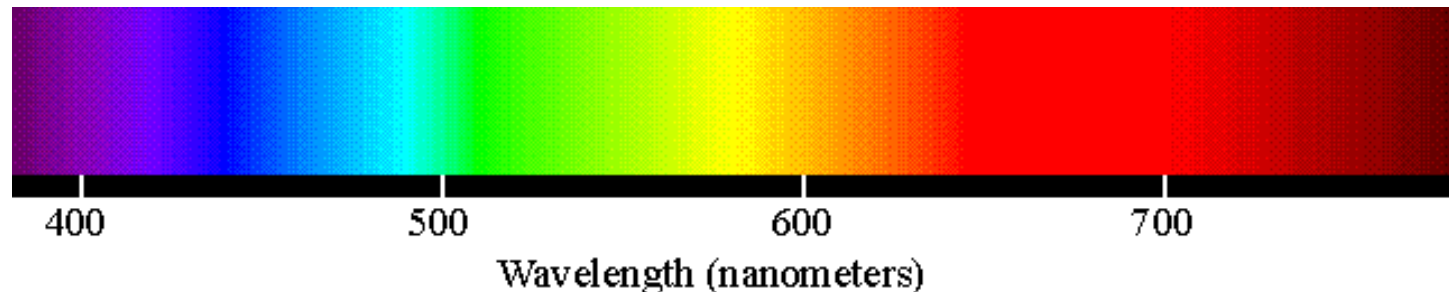
- Hold grating by the edges. Oil from your hands can fill in the slits and ruin the grating
- Hold close to your (open) eye and look for rainbow from lights
- Rotate grating until rainbow is horizontal.

White light contains the entire spectrum.

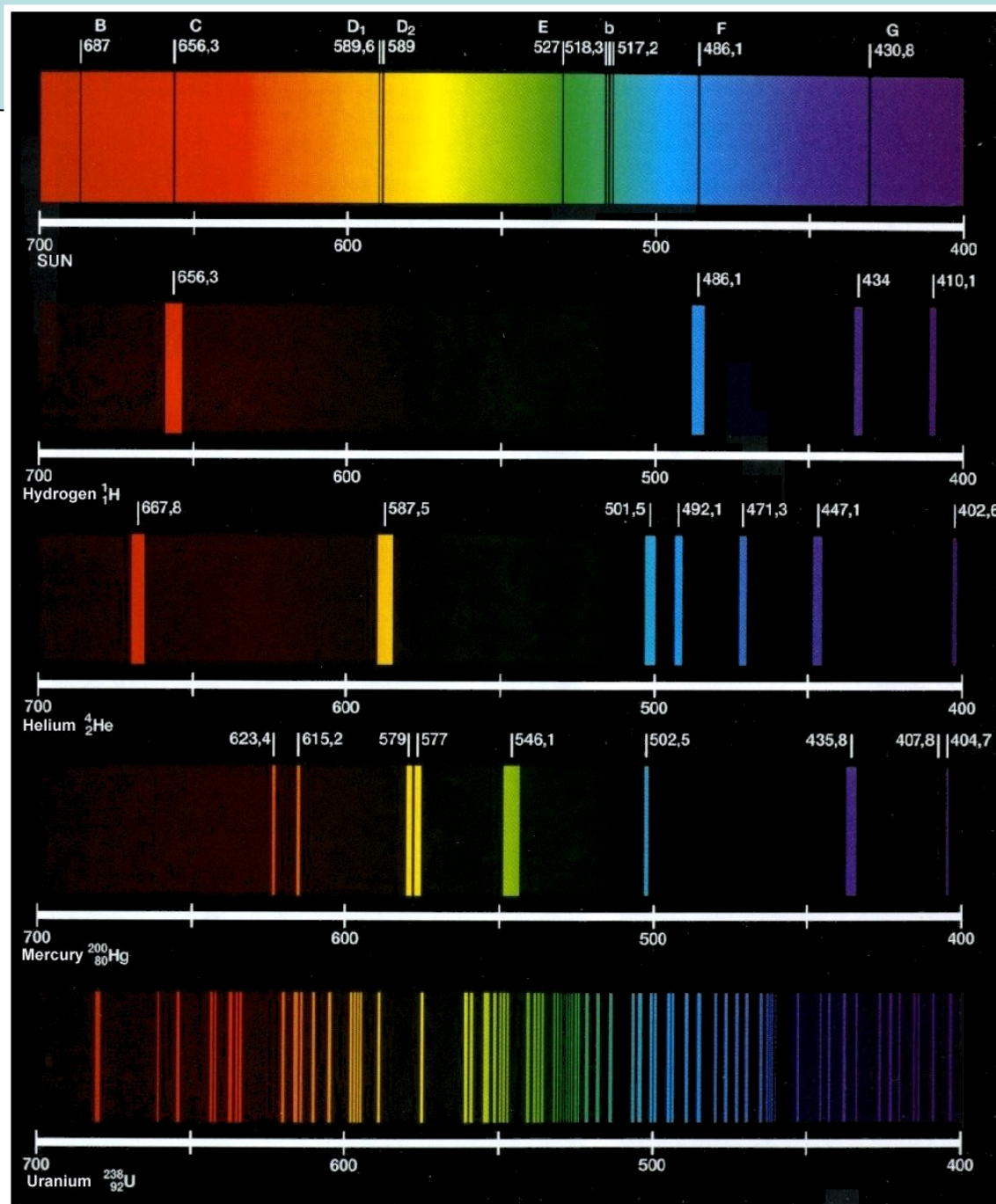
Each atom has a unique set of colors, also called lines. The whole set is an atom's spectrum.

Note which colors you see from the various lamps.

Can also view street lights (some are sodium or mercury)



Atomic Spectra:

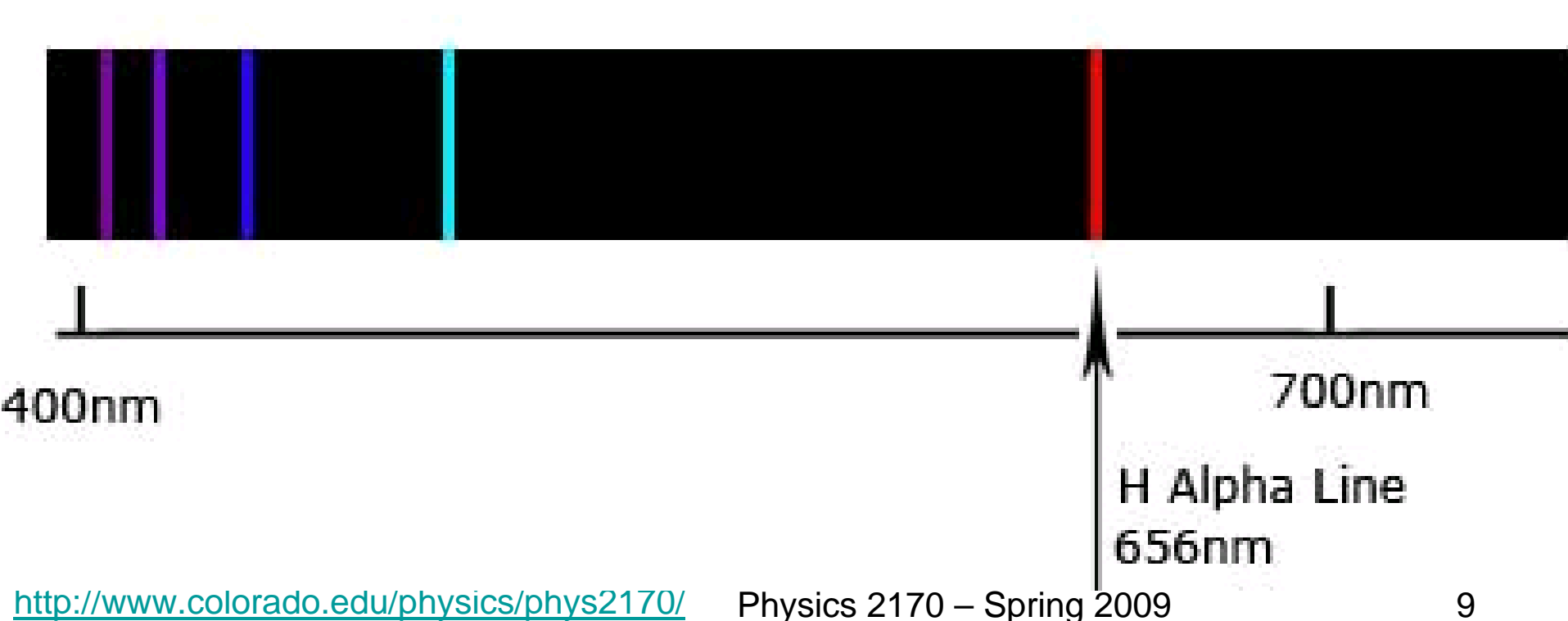


Each type of atom produces unique set of colors.

Discussion

Given that we know light comes in photons with energy $E = hc/\lambda$, what do these atomic spectra observations imply about electrons in atoms?

Hydrogen Emission Spectrum



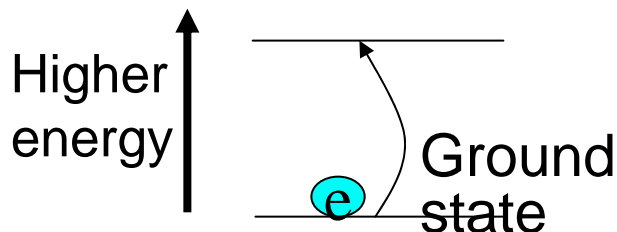
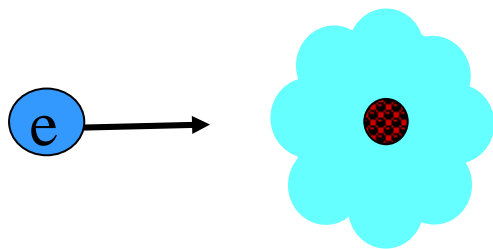
What does the observation of the atomic spectra tell us?

- Implies that electrons only change between very specific energies
- The only way for individual atoms to give off energy is as light
- Each time a photon is emitted an electron must be changing in energy by that amount (releasing energy)

Atoms are lazy - always want to go back to lowest energy state.

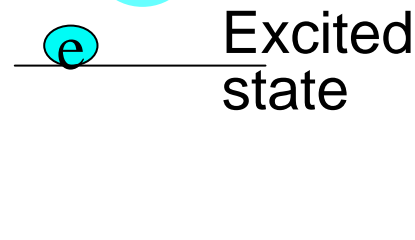
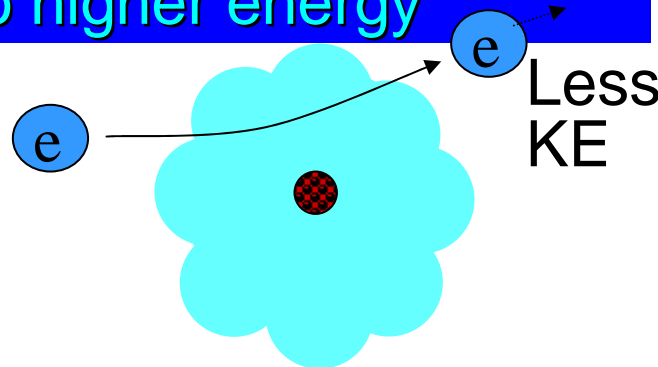
Step 1

Free electron hits atom



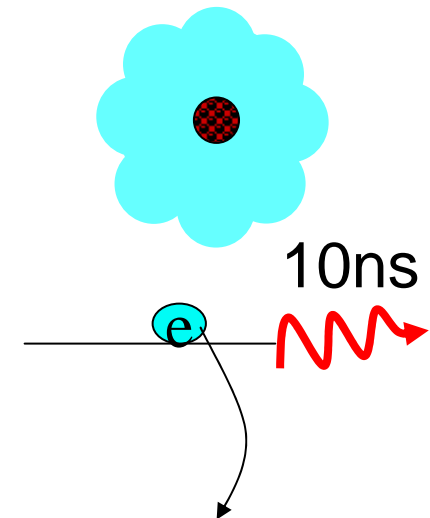
Step 2

Atomic electron excited to higher energy



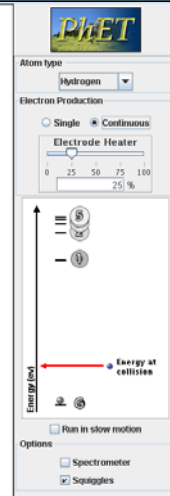
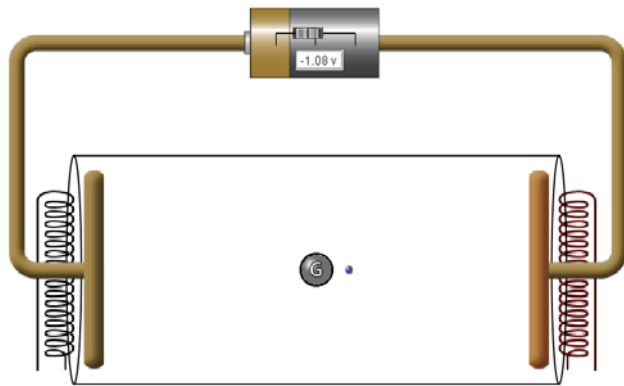
Step 3

Electron jumps back to low energy

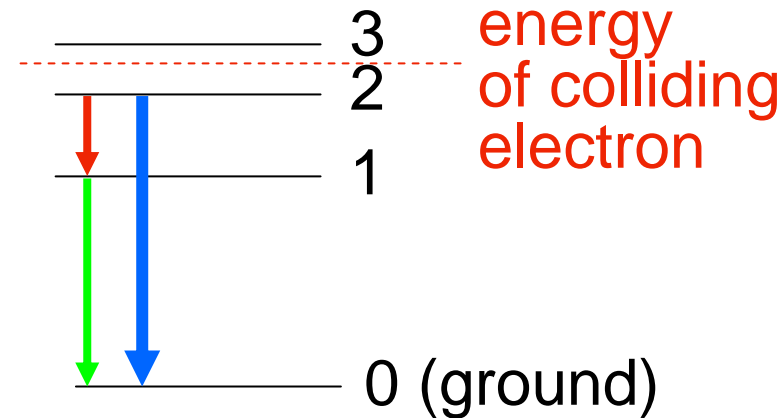


Clicker question 1

Set frequency to DA



Atomic energy levels

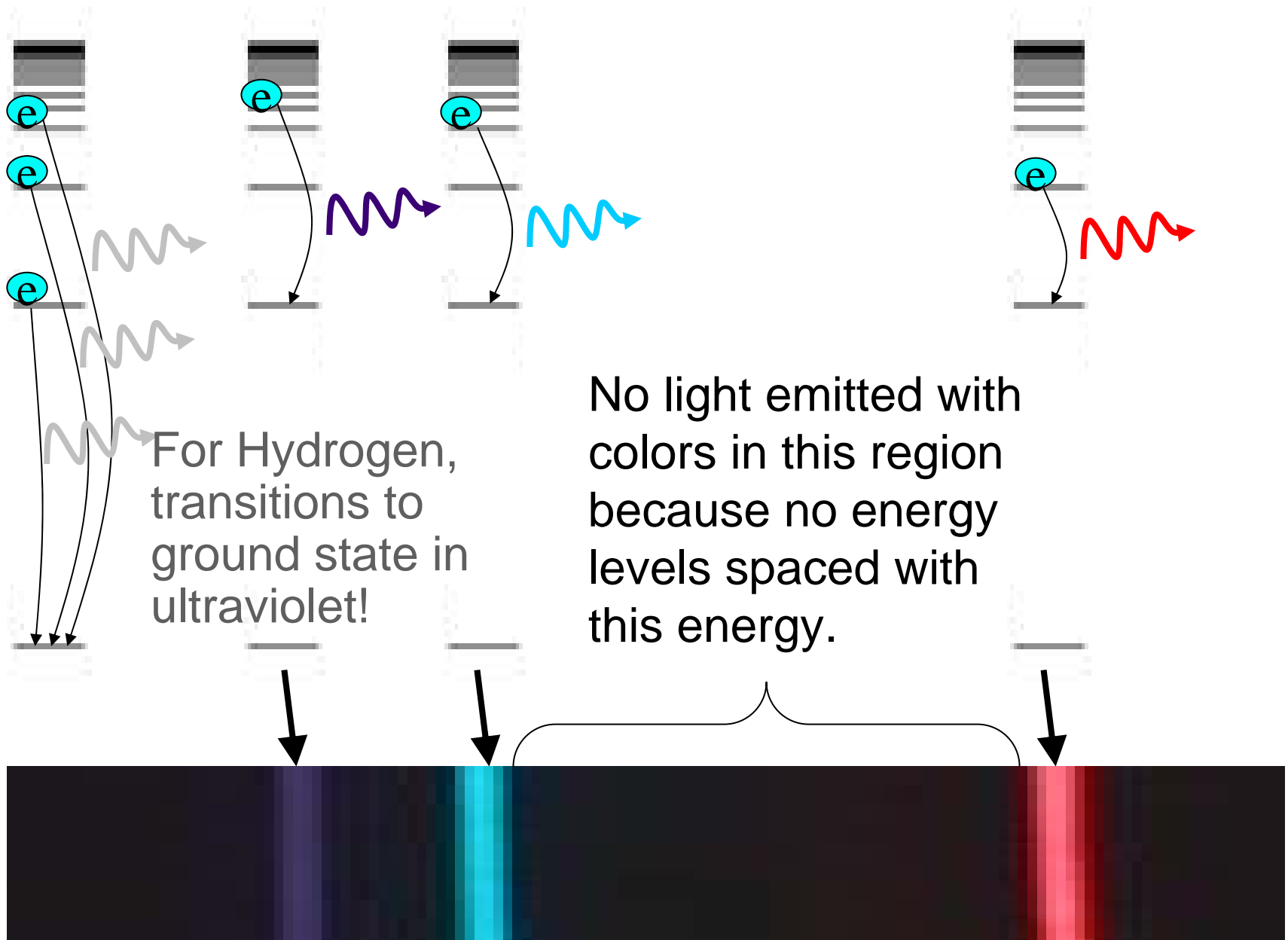


If the colliding electrons have an energy between that of level 2 and level 3 when they hit the atom then...

- A. No light will come from the atom
- B. One color of light will be emitted from the atom
- C. Two colors of light will be emitted from the atom
- D. Three colors of light will be emitted from the atom**
- E. Four or more colors of light will be emitted from the atom

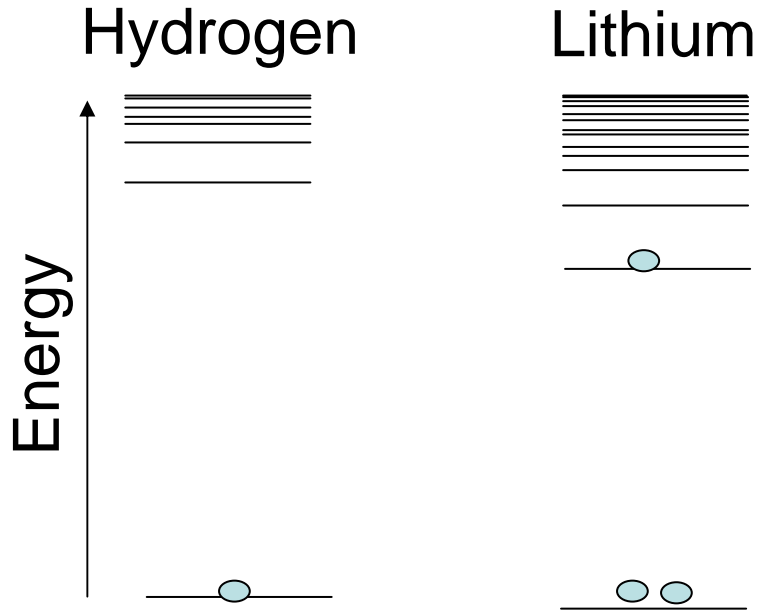
Enough energy to excite level 2, then get $2 \Rightarrow 1$ followed by $1 \Rightarrow G$, but also can go $2 \Rightarrow G$.

Energy level diagrams show the energies the electrons can have.



Summary of atomic energy levels

- 1) Electrons in atoms only found in specific energy levels.
- 2) Different set of energy levels for different atoms.
- 3) 1 photon emitted per electron jump down between energy levels. Photon color determined by energy difference.
- 4) Electron spends very little time (10^{-8} s) in excited state before hopping back down to lowest unfilled level.
- 5) An electron not stuck in an atom is *free*; can have any energy.



Electron energy levels in 2 different atoms ...

Levels have different spacing.

Atoms with more than one electron ... lower levels filled.