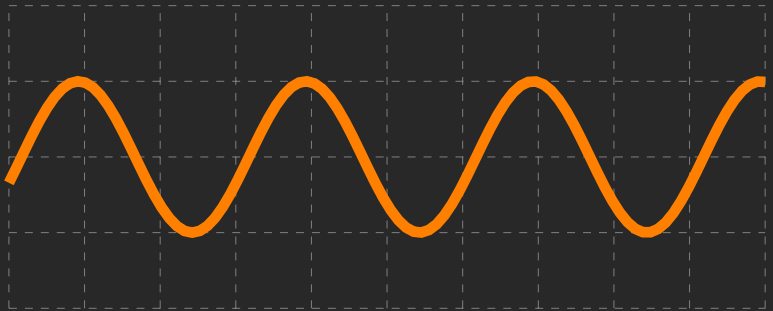
Announcements

- WebWorK due Friday
- Test 1 is a week from Friday!
  - Old tests and review questions will be posted Friday so you can start studying
  - Lecture review questions and understanding checks also a good source to check yourself
  - I'm working to get the equation page updated and posted
- Polling: `rembold-class.ddns.net`

Review Question

Given the wave below, what is the wavelength of the wave? Each grid is 1 meter.

A. 1 m
B. 1.5 m
C. 3 m
D. 10 m



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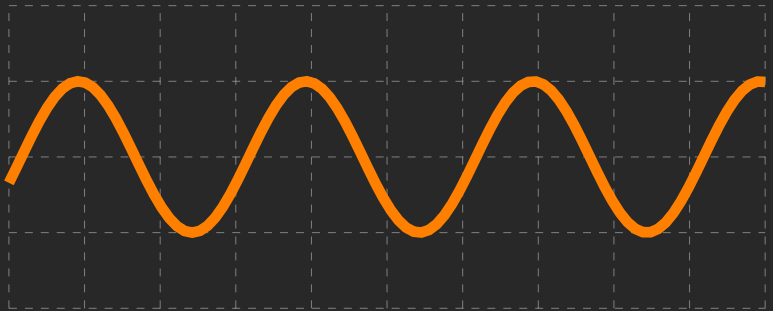
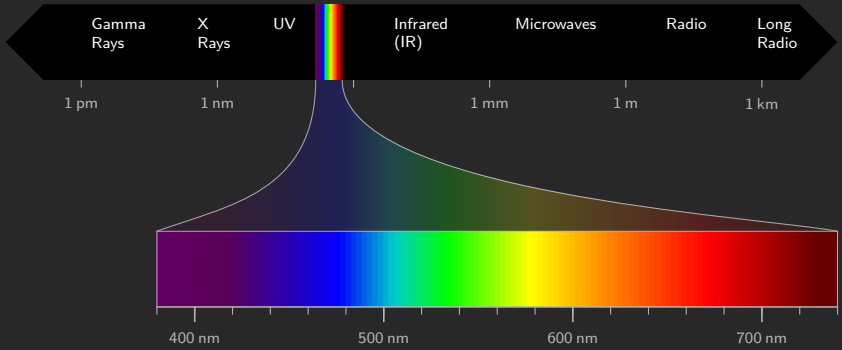
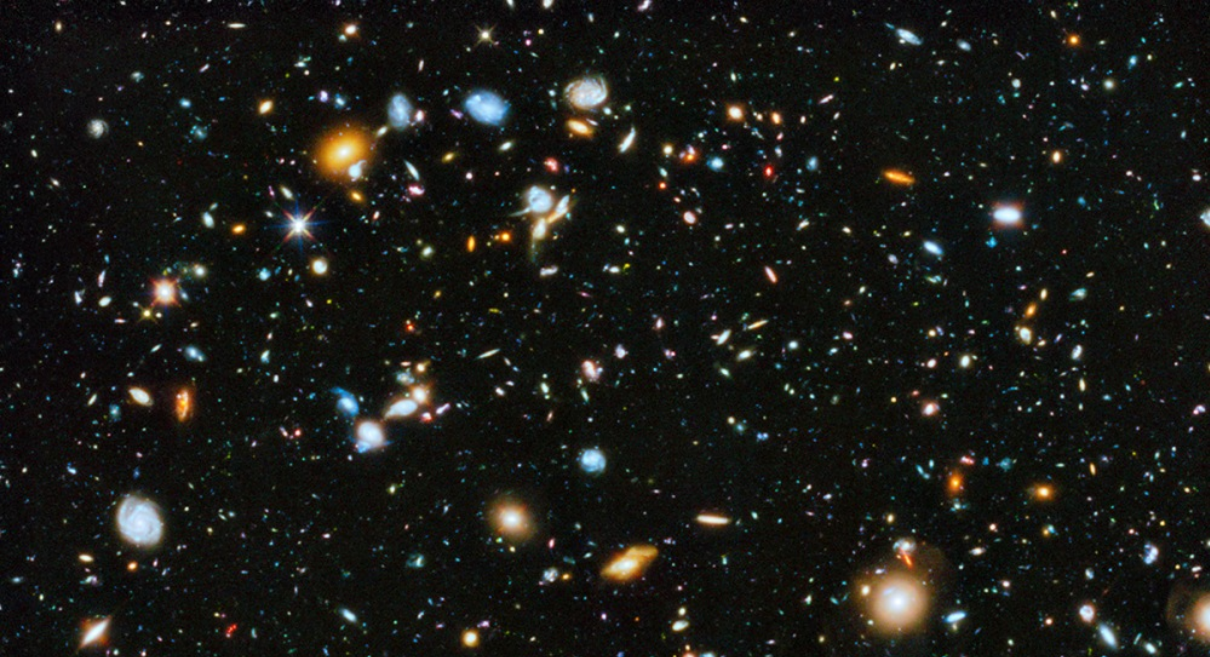


I'm (Mostly) Blind!



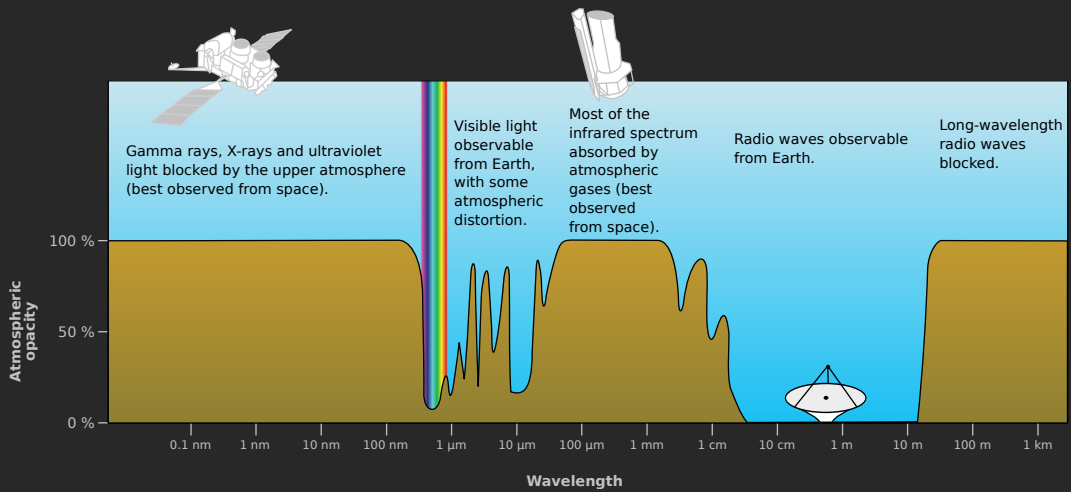
Please just pause a moment and appreciate this lovely thing that I spend forever on...



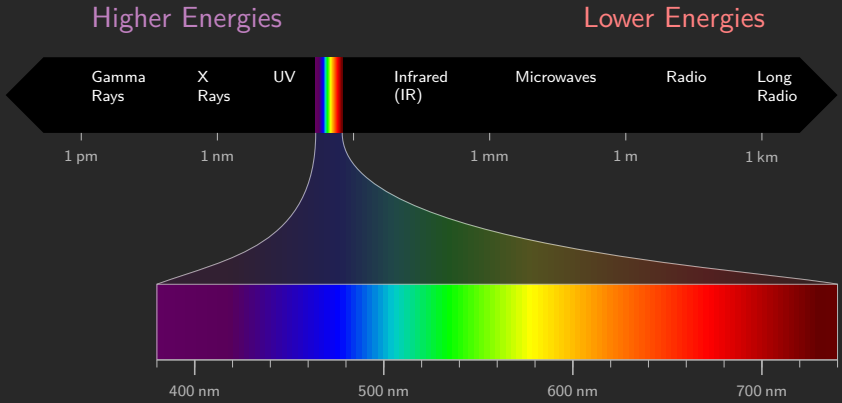
Everything the Light touches...

- Everything that emits or reflects light we can observe
- The visible bits are just a tiny fraction of the huge spectrum of possibilities
- Gives rise to different forms of astronomy:
  - Optical
  - Radio
  - Microwave
  - High Energy (Gamma/X Ray)

Some more difficult than others. . .



Back to the Spectrum



How to make some light...

- The general term electromagnetic radiation describes all the frequencies, not just the visible ones we generally call "light"
- How do we produce EM-radiation?
  - Take something hot...

- What wavelengths are emitted depend on the objects temperature

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  - Hot object produce more radiation in general
  - Hot objects produce more radiation at shorter wavelengths

A shining example (ba-dump tssh)

- Star color depends on the star's temperature!
- The brightness we see also depends on the star's size and distance from us (more on that later!)

Brighter and Bluer...

- So hotter objects radiate both
  - more total radiation and
  - lower wavelength radiation
- Qualitatively this moves our spectrum to the left and makes it taller
- Quantitatively, we can describe this effect through two laws!
  - Stefan-Boltzmann Law
  - Wien's Law

Important!

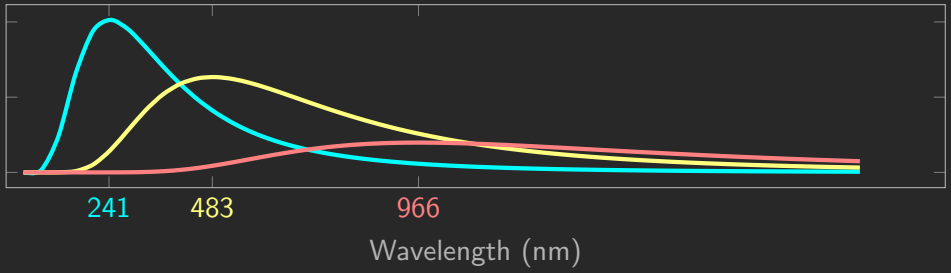
Increasing an object'ss temperature causes it to emit light that is both bluer (of a lower average wavelength) and brighter (of a greater amplitude)

Wien's Law

- Wien's Law tells us at what wavelength the *peak* of the spectral curve lies.
- Thus it gives us information about the color
- Very simple relation:

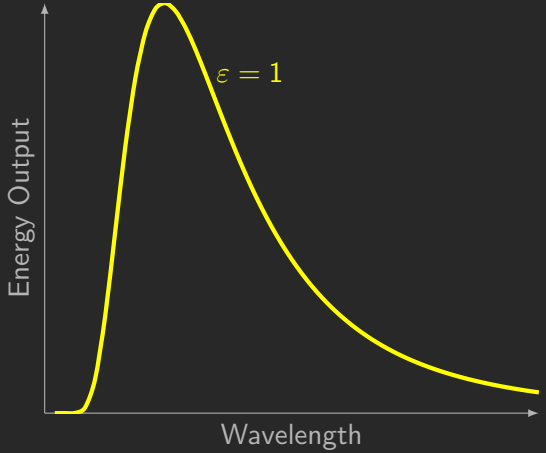
$$\lambda_{max}(\text{nm}) \approx \frac{2900000}{T}$$

- Note that this equation gives you the wavelength in nanometers!



Life is complicated

- Unfortunately, not everything radiates as well as coals or stars
- How well an object radiates is called it's emissivity (ε)



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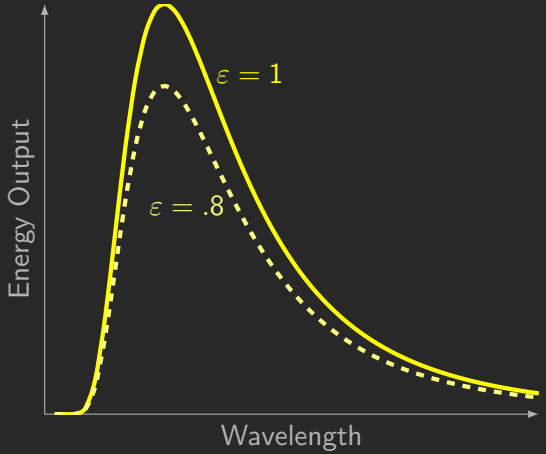

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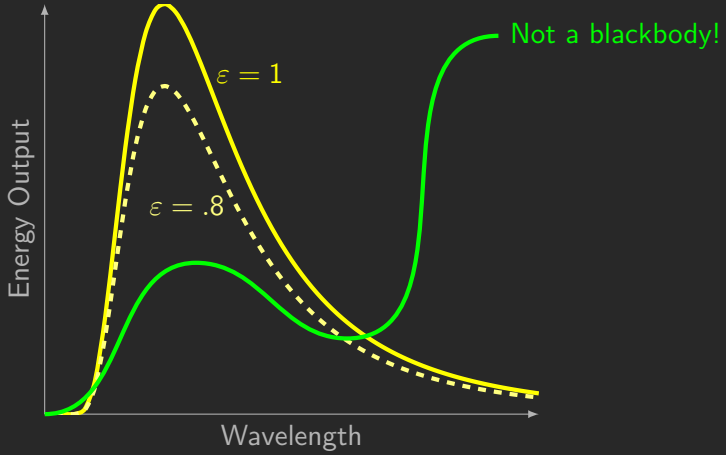

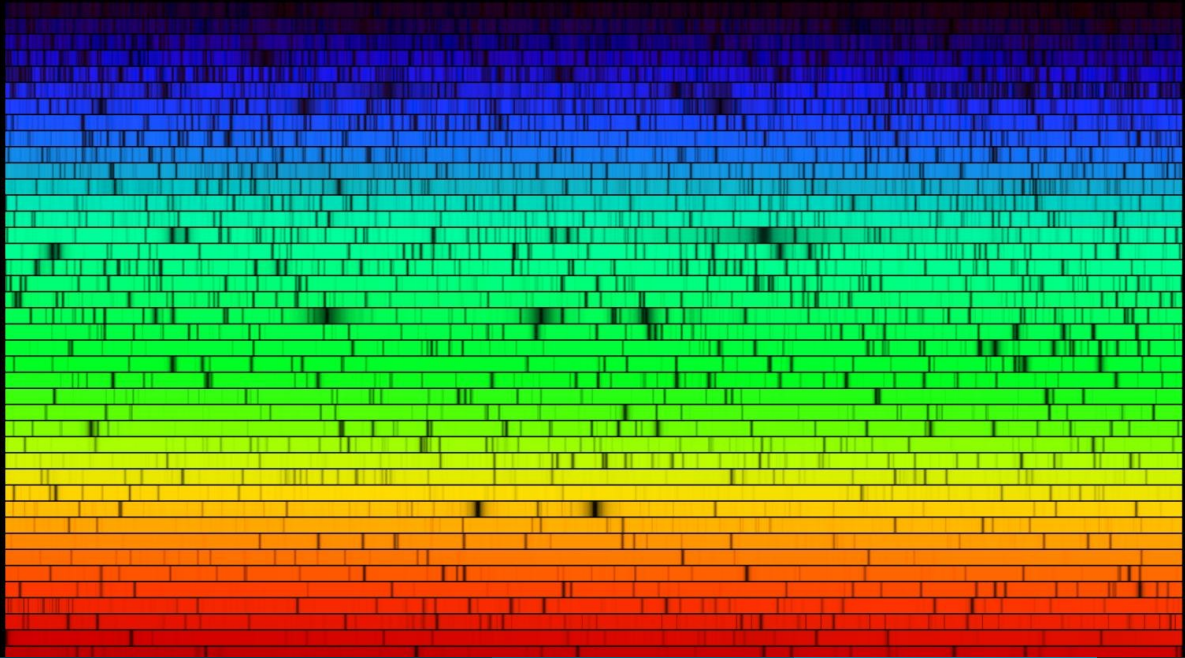

Spectra and Composition

- Objects with thermal spectra are generally dense (wood, rocks, people, metals, stars,. . .)
- A perfect "blackbody" spectrum would *only* give us information about the temperature
- Diffuse gases have a more complex spectra, and indeed one that gives information about their chemical composition

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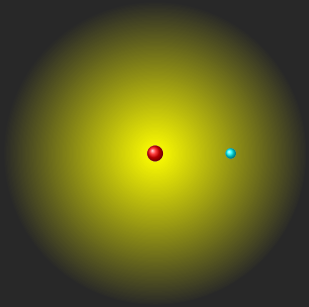
- A perfect "blackbody" spectrum would *only* give us information about the temperature
- Diffuse gases have a more complex spectra, and indeed one that gives information about their chemical composition
  - Why is gas so special?

Life of an Electron

- Electrons orbit around the nucleus of an atom



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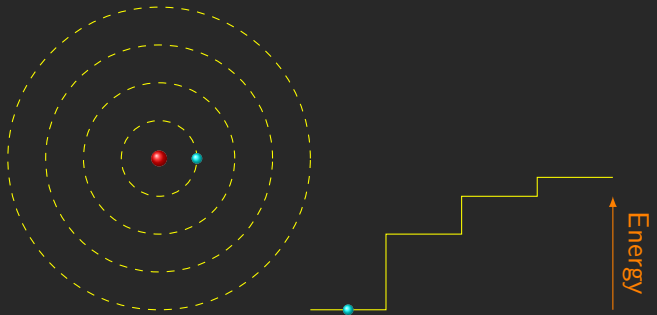

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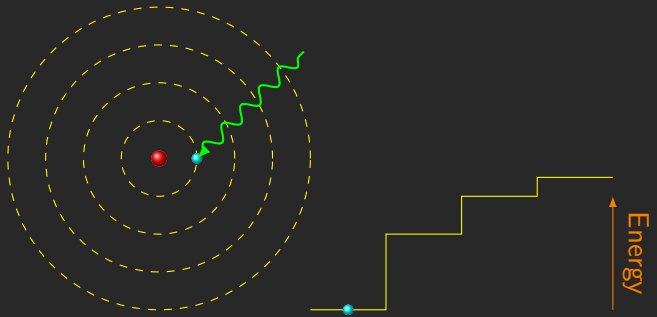

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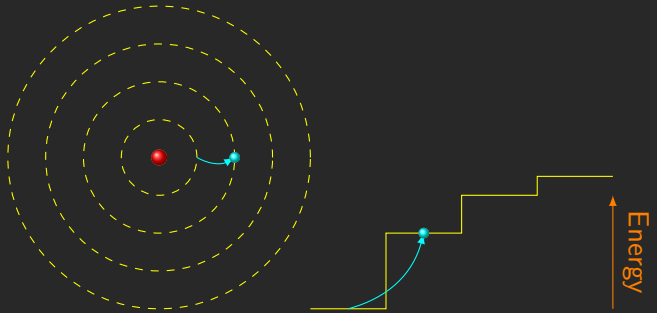

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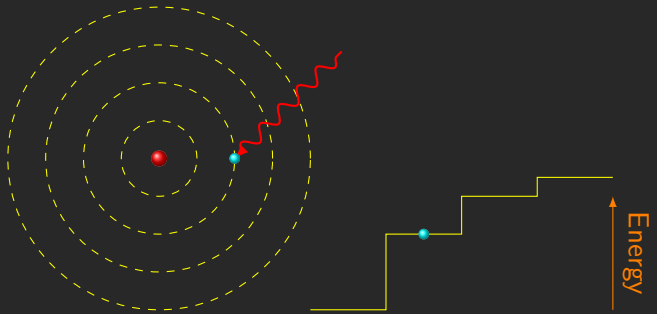

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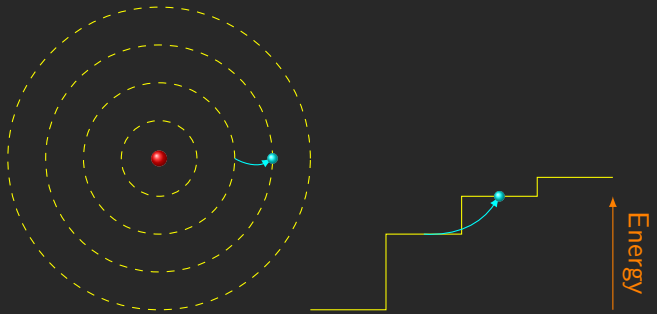

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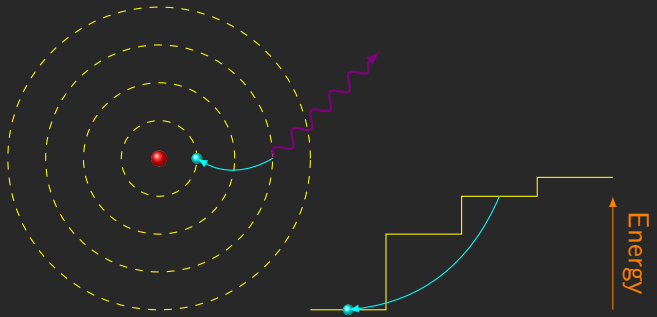
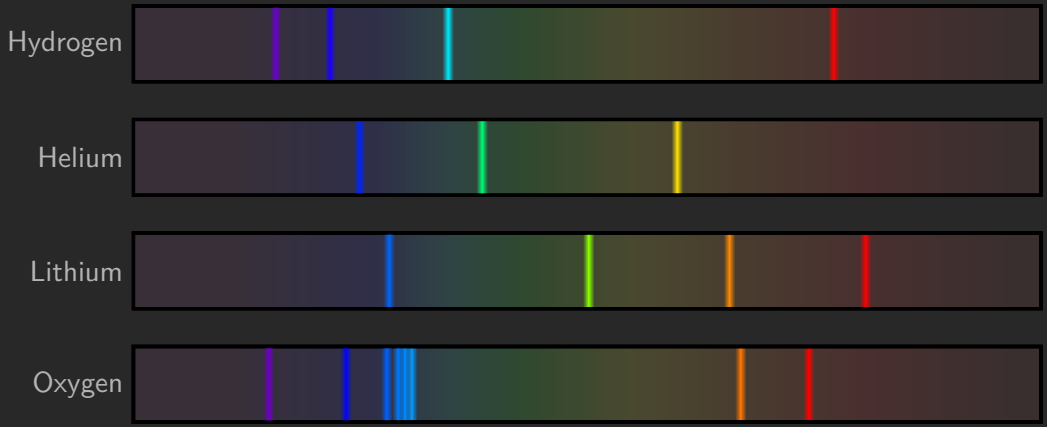


Fingerprinting Light

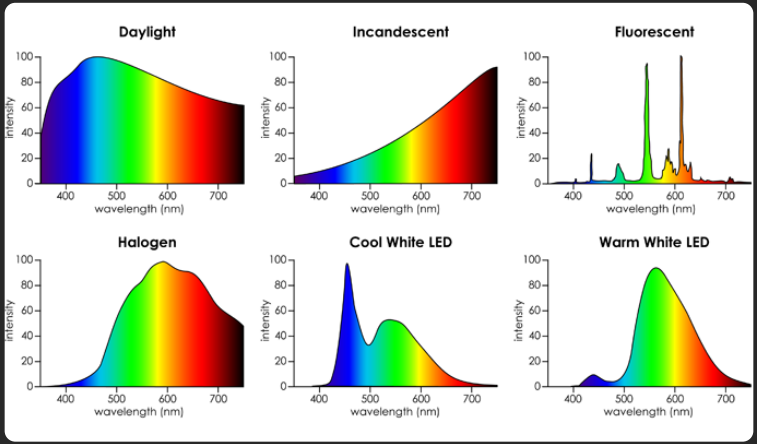
- These quantized energy levels give atoms line spectra
- These spectra work as fingerprints for atoms and molecules!



Lightbulb!

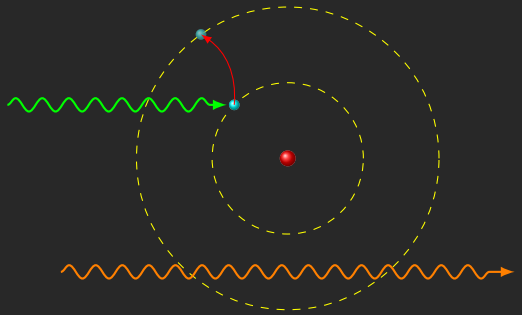
- Incandescent bulbs:
  - Hot, glowing filament
  - Gives a black body spectra
  - Lot of it's radiation is in the IR
- Fluorescent Lights (or vapor lamps)
  - Electrically "excited" gas
  - Give a line spectra
  - Generally more efficient
  - May look "unnatural"

Lightbulb Spectra



Absorption Spectra and Goldilocks

- What if we have a cooler gas, but with light shining on it?
- Some of the radiation will be absorbed
- Only the "just right" wavelengths corresponding to the energy steps



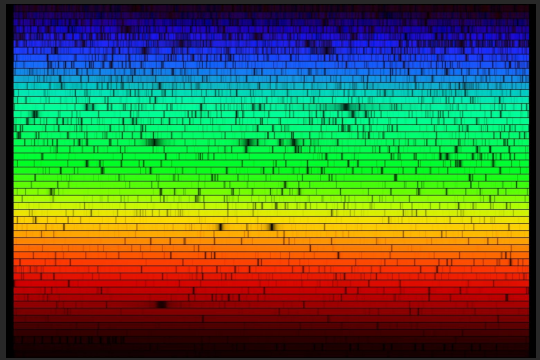
Sample Case: Hydrogen

Hydrogen Emission Spectra

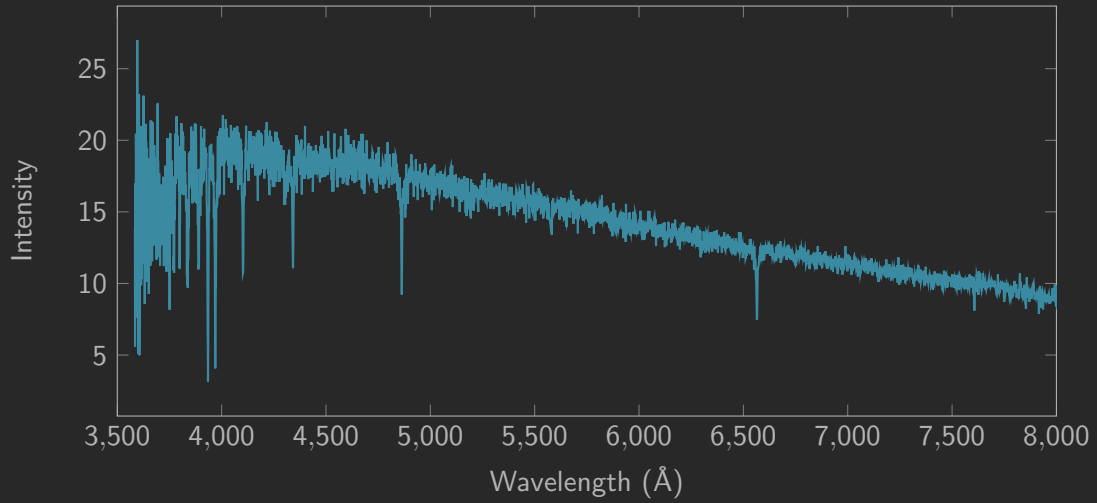
Hydrogen Absorption Spectra

That Spectra is Stellar!

- You see absorption lines in spectra of stars
- Stars emit a blackbody spectrum, which depends on the star's temperature
- Thinner and cooler gas at the star's surface absorb some wavelengths



Viewing Absorption Differently



Recap

- A hot, dense source emits a continuous spectra

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- Hot diffuse gases emit line spectra

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- Cooler gases in front of hot sources create absorption lines