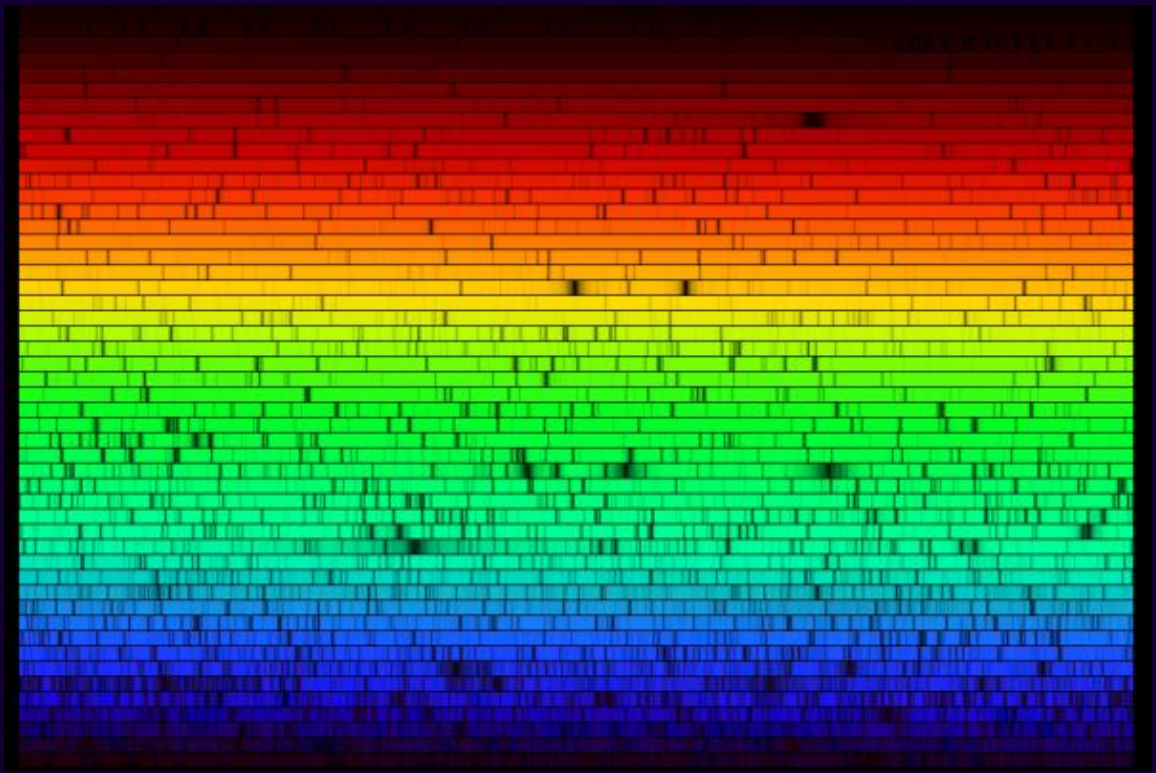
Thermal radiation

Astronomy 101
Syracuse University, Fall 2016
Walter Freeman

November 1, 2016



Announcements

- Provisional study guide posted
- May be revised on Friday once I see how far we get Thursday
- Short Mastering Astronomy assignment posted late today, due Tuesday
- Will catch up on email tomorrow morning

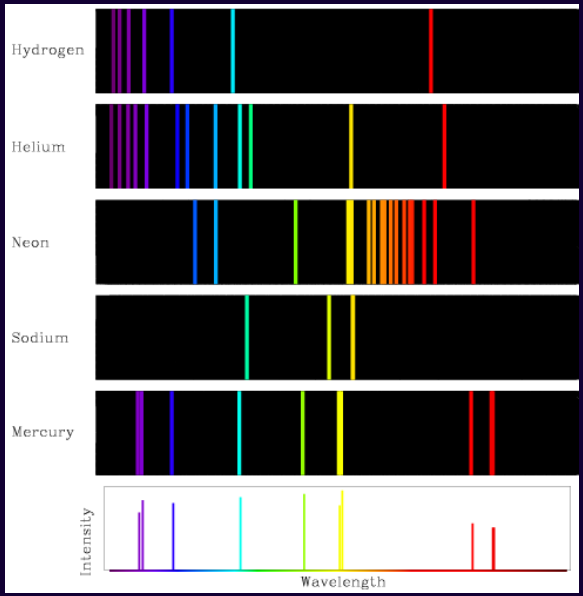
Exam preparation schedule

- Clinic hours tonight (4:30-6:30)
- Quick answers to study questions all day Wednesday
- Help session Friday held in room 208 from 9:30-11:30 and in the Clinic from 1:30-3:30
- Review on Sunday:
  - A: 2:30 PM-5 PM
  - B: 8:30 PM-11:30 PM
- Extended clinic hours next Monday: 2PM-6PM

Emission spectra

Last time we saw that atoms can emit light of particular wavelengths/energies corresponding to their atomic transitions.

This gives us *emission spectra* consisting of bright lines (from NMSU Astronomy):



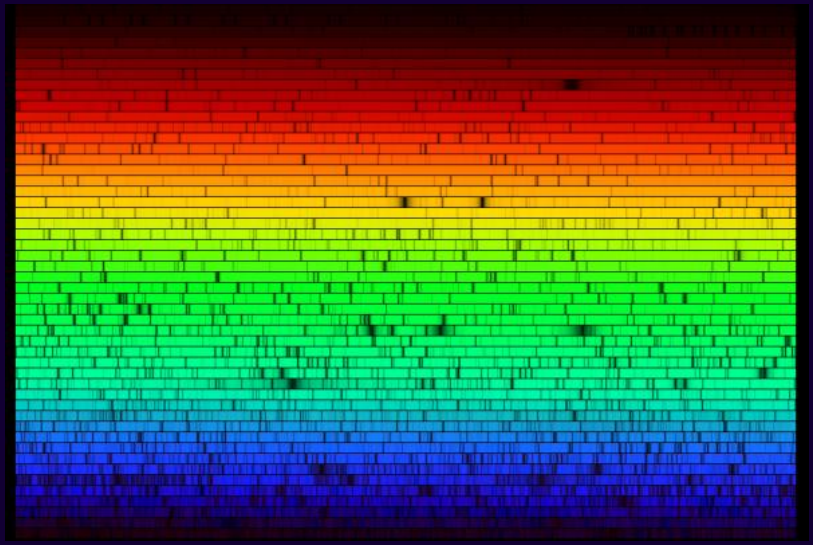
Absorption spectra

Elements can also *absorb* wavelengths of these particular wavelengths as well.

(Remember that these atomic transitions can go both ways.)

Other colors simply pass through.

(Molecules have these spectra too: their electron energy levels are more complicated.)



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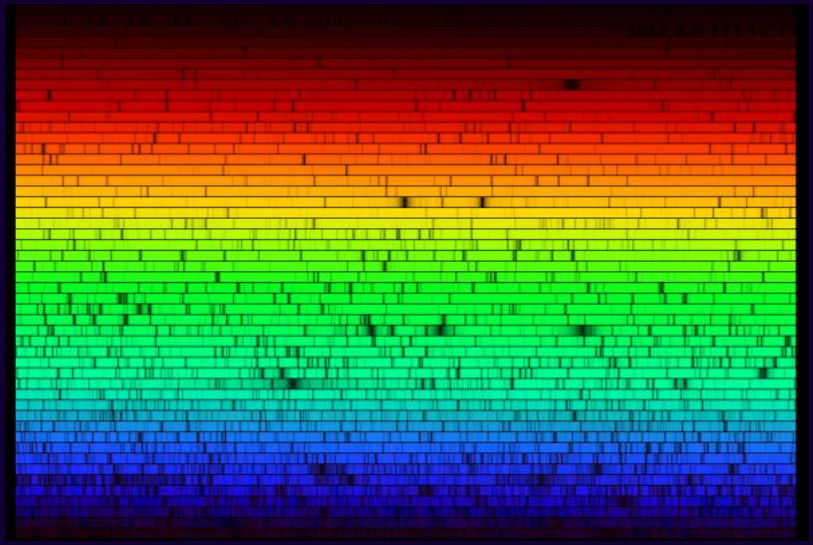

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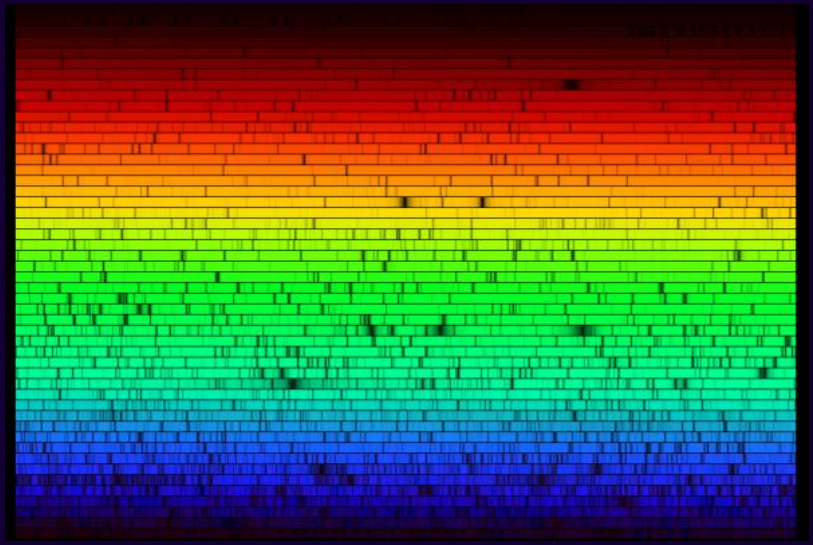

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This picture tells us what's in the Sun!

You discover lines in the solar spectrum that don't correspond to any known element. What do you conclude?

A: Something about quantum mechanics is different in the Sun

B: Something about light is different in the Sun

C: There's an element in the Sun that's not on Earth – call it **sunium**

D: The extreme temperature of the Sun causes new lines to appear in its gas

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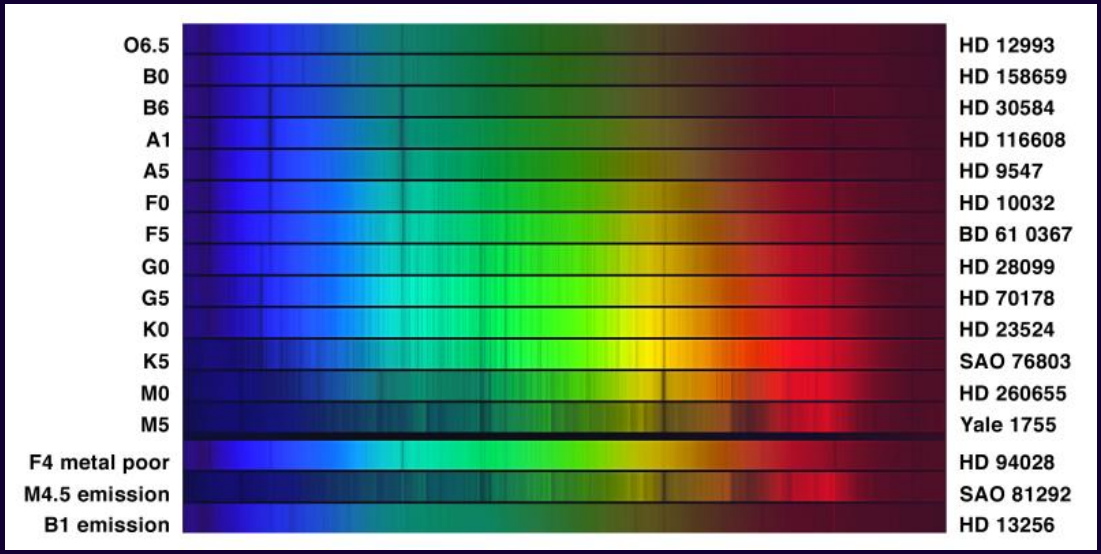
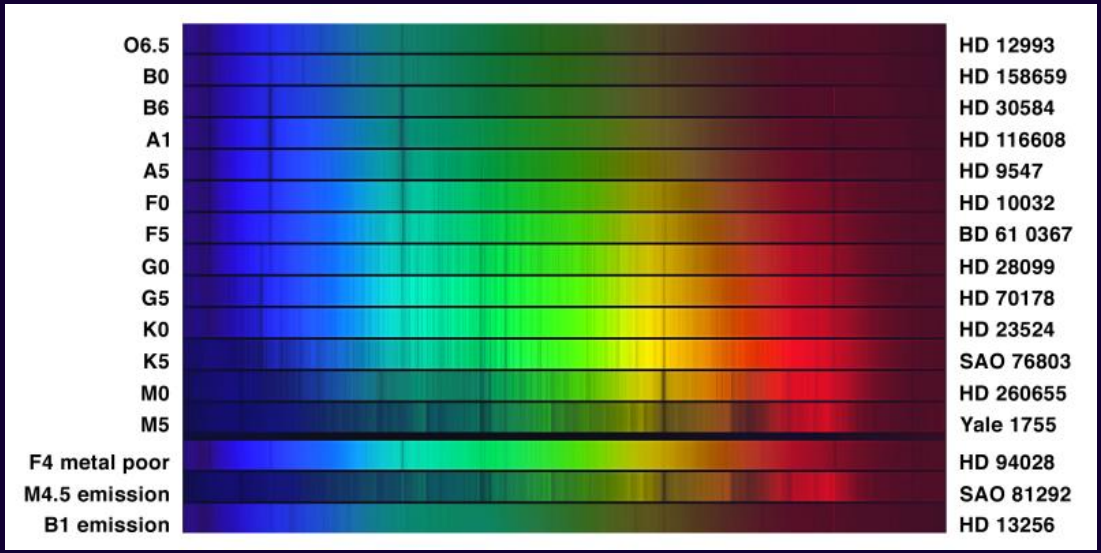
D: The extreme temperature of the Sun causes new lines to appear in its gas

E: "Sunium"? There's no such element!



All the stars are made of the same stuff – the same stuff as we are.



All the stars are made of the same stuff – the same stuff as we are.

"The cosmos is also within us. We are made of star-stuff. We are a way for the universe to know itself."

–Carl Sagan, *Cosmos*

What a lucky accident!

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There are others that are very interesting to astronomers:

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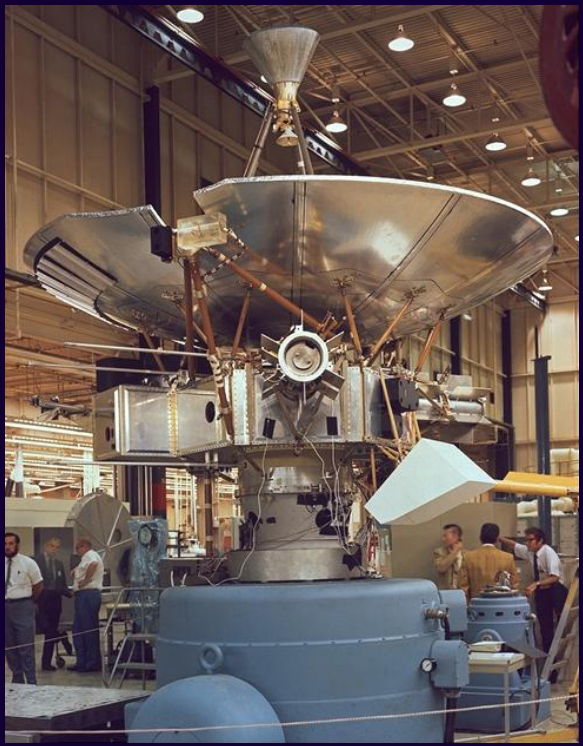
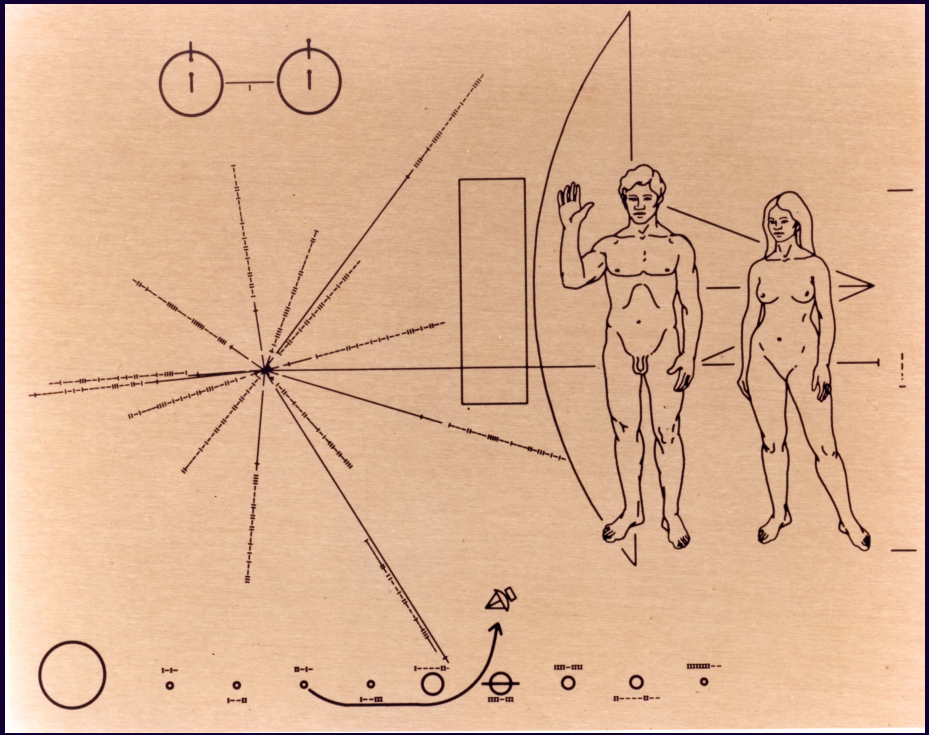
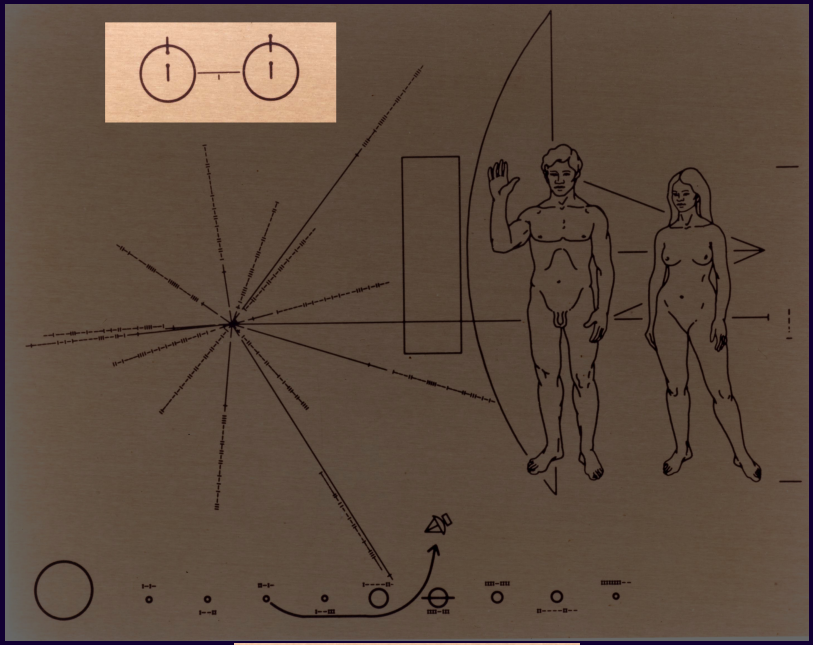
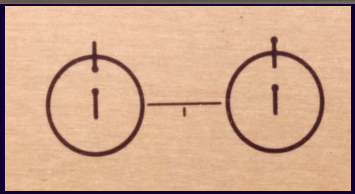
- Molecular vibrations: infrared
- Molecular *rotations*: microwave
- "Hyperfine structure" energy levels in hydrogen: 21 cm radio waves

This last is particularly interesting: it is a very particular frequency, echoing out from all corners of the Universe, that says: hydrogen is here. (Hydrogen is 75% of the universe.)









If Nature has a ruler, its markings are 21 cm apart.

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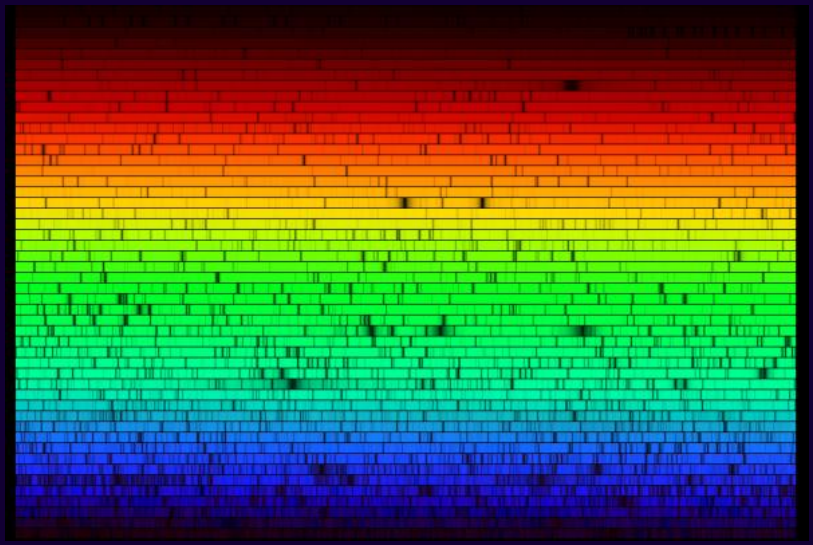
(TRF people: it's the 60Hz-hum of the universe. :))

Let's look at that solar spectrum again:



We understand why the dark lines are where they are. But where does that continuous spectrum – light of *all* wavelengths – come from in the first place?

Thermal radiation

Objects glow because they're hot.

- Any object with a temperature emits electromagnetic radiation ("light").
- For objects as warm as we are, this is in the "far infrared".
- As objects heat up, the peak wavelength decreases (the average photon energy increases)
- As objects heat up, the total intensity emitted goes up *rapidly* (proportional to T^4)
- This is also called "blackbody radiation" (since even a black object glows if it's warmed up)

See the simulation to see how this works...

Done!

This is all the physics you need to know.

Complete *Lecture Tutorials* pp. 59-61 (skip 62).

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Finish up *Lecture Tutorials* pp. 65-69.