Thermal radiation and spectroscopy

Astronomy 101
Syracuse University, Fall 2019
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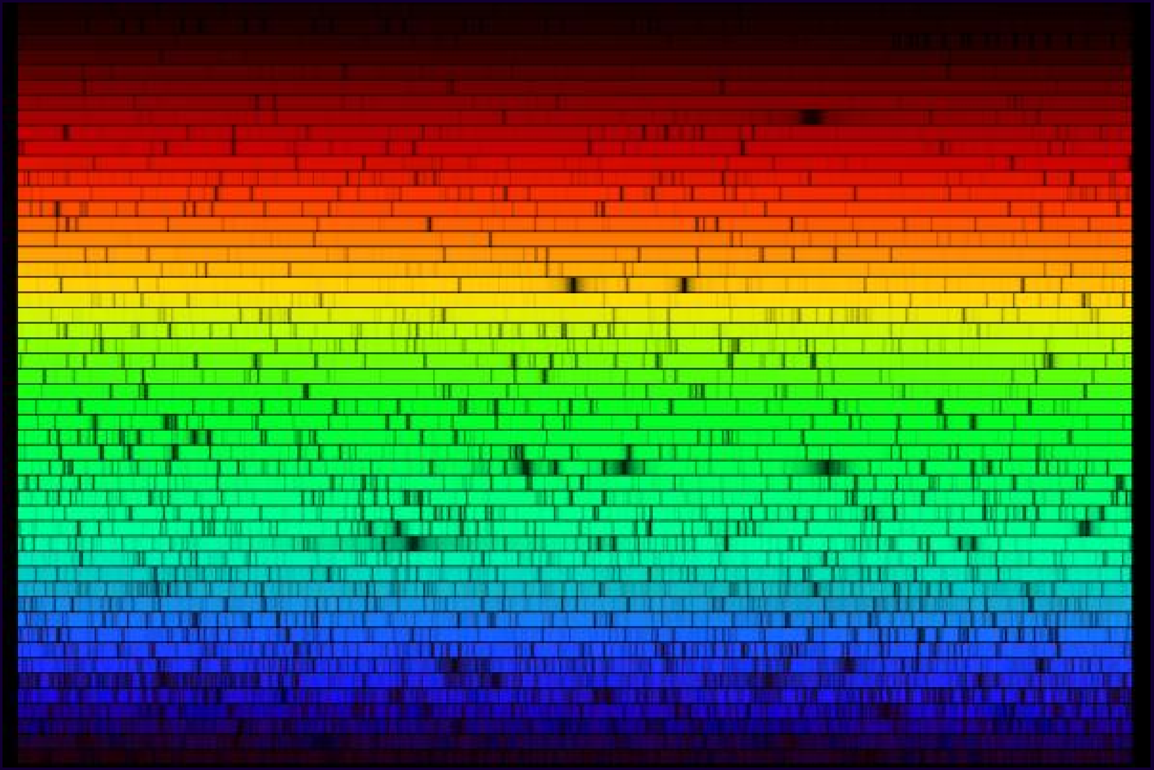
October 24, 2019



Announcements

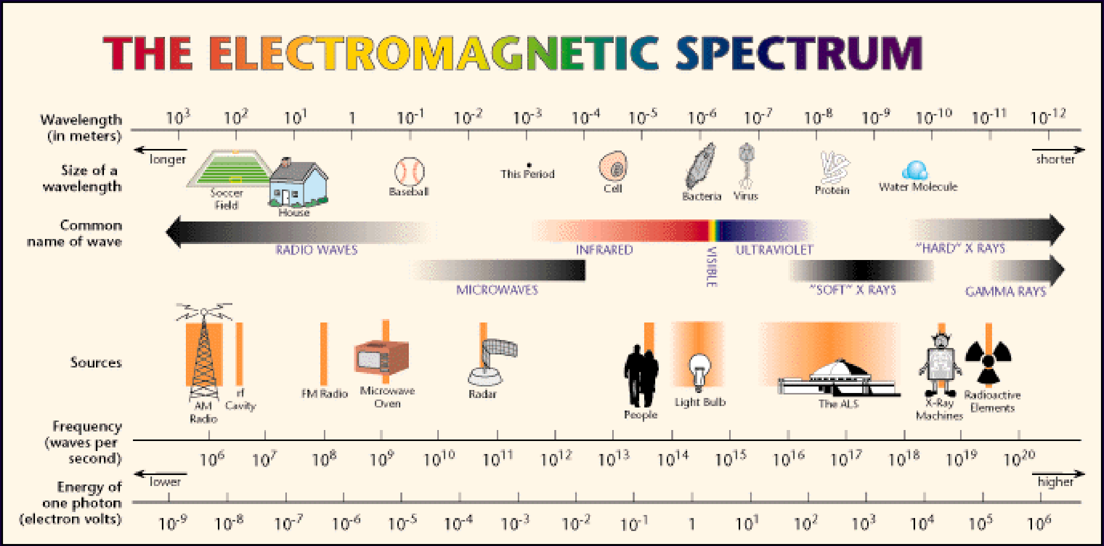
- Paper 2 topic available for those absent Tuesday
- Answering mail as fast as I can; should be through my backlog soon

At what point does spaghettification occur?

–Harris Krahn

Lots of folks are curious about different types of “radiation” – in particular, how it can affect human health.

Do you have any questions about this?



Light and spectra

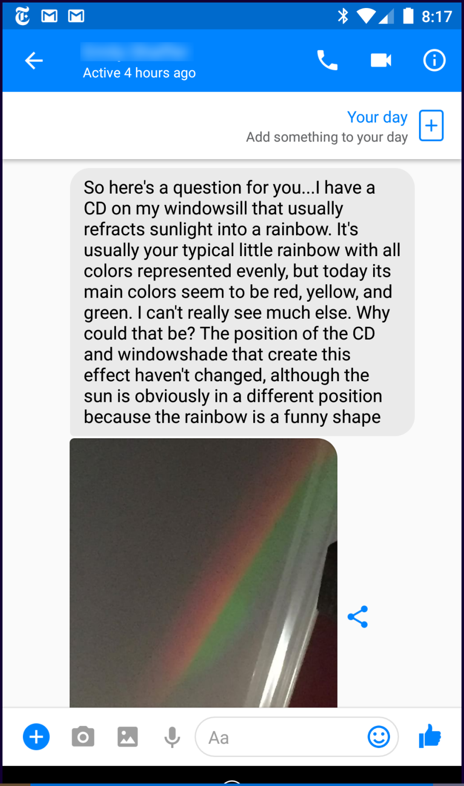
White light isn't really white; it's a mix of many colors (wavelengths).

Our eyes are very limited; we can only distinguish between three colors.

We can learn a lot about an object by the colors of light it emits, but we have to be able to see them first!

We do that by spreading them out. Then we can see what colors are there in great detail.

A friend sent me this two years ago, the day before this topic:



The two pictures:

Shortly after sunrise:

Later in the day:

The two pictures:

Shortly after sunrise:

Later in the day:

What is different?

What happened here?

A: There's less blue light right after sunrise because the Sun is different then

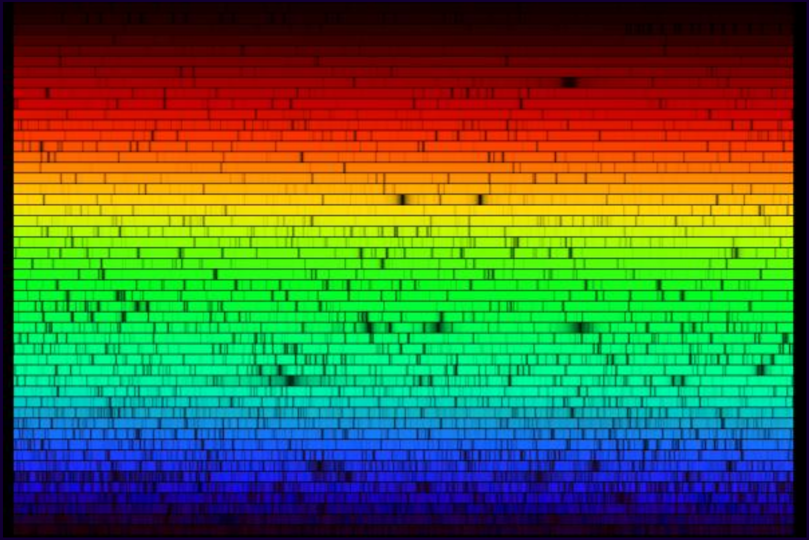
B: The colors are in a different order earlier in the day

C: All the colors are fainter right after sunrise

D: There's less blue light right after sunrise because something happened to the light as it was traveling here

Light and spectra

Let's look at that picture of the Sun again:



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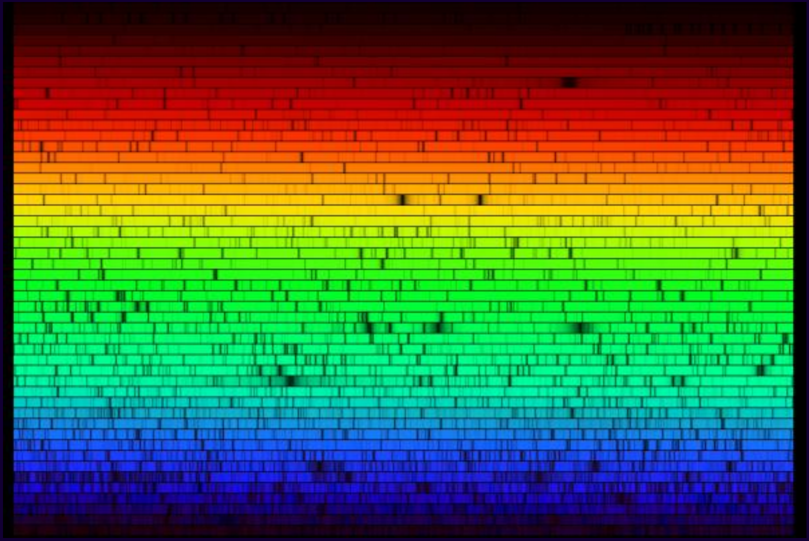

Need to understand:

- Where did all those colors come from in the first place? (today)
- Why are there dark lines? (next Tuesday)

Why does the sun shine?

A: Chemical reactions make light!

B: Nuclear reactions make light!

C: It's really hot, so it glows

D: That's just what stars do

Why does the sun shine?

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E: Google to the rescue!

Incandescence

"The sun is a mass of incandescent gas" – what does that mean?

Objects glow because they're hot. This is called *thermal radiation.*

- 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...

Takeaways: thermal radiation

- Any object with a temperature glows
- Hotter objects glow "bluer" (shorter wavelengths) and brighter
- Hotter objects emit more light per unit area (of all wavelengths)
- A larger object that is cold (large red star) may emit more total light than a small object that is hot (small yellow star)
- This glow is a *broad spread of wavelengths* – there aren't narrow bright or dark lines in it

What will happen if I turn the power up on the lamp?

A: The height of the graph will go up

B: The graph will shift left

C: The graph will shift right

D: The height of the graph will go down

Complete *Lecture Tutorials* pp. 59-62.

We will learn about those dark lines after this.

Another table

It's important to know, roughly, what temperature objects emit radiation of what wavelengths (mostly):

Name	Temp (Kelvin)	Temp (Celsius)	Object
Microwaves	3	-270	The universe itself
Infrared	300	30	Stuff on Earth
Near infrared	1500	1200	A candle flame (mostly IR, some red)
Visible (middle)	5000	5000	A star like the Sun
Ultraviolet	Tens of thousands	Tens of thousands	A very hot star, like Rigel
X-ray	Millions	Millions	Gas falling into a black hole

What will happen if I put a colored plate in between?

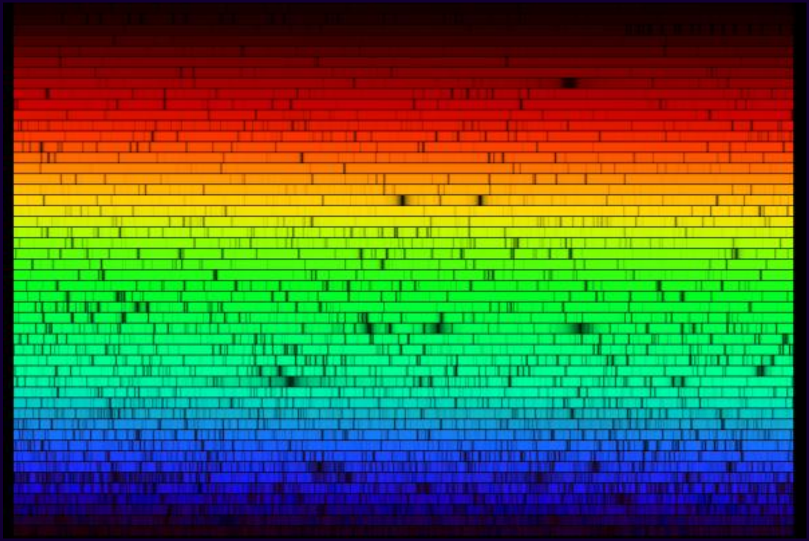
A: The height of the graph will go down

B: A narrow dip will appear in the graph

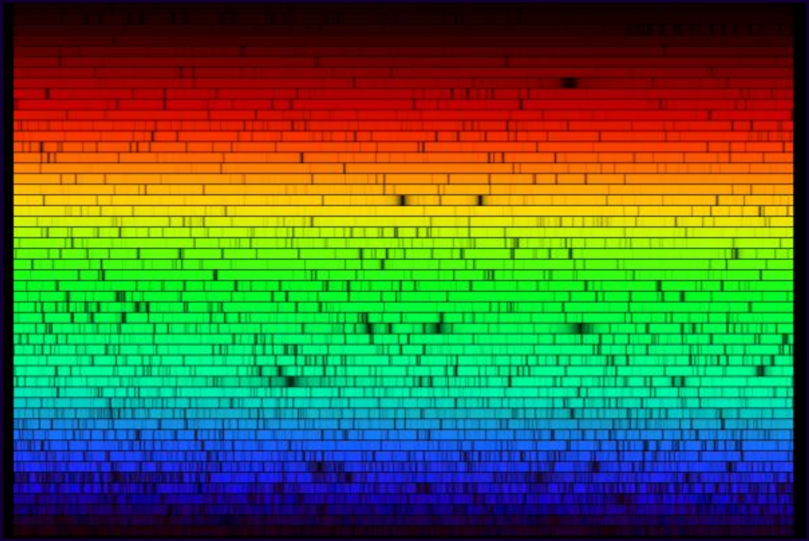
C: A narrow peak will appear in the graph

D: The graph will shift left

E: The graph will shift right



- The hot core of the Sun emits light of all wavelengths



- The hot core of the Sun emits light of all wavelengths
- The gases in the cooler atmosphere absorb very particular colors ... but why, and which ones?

Chemistry 101 in a nutshell

(on the document camera)

Start on *Lecture Tutorials* pp. 65-69.

This is the crux of this unit, so ask lots of questions to us!