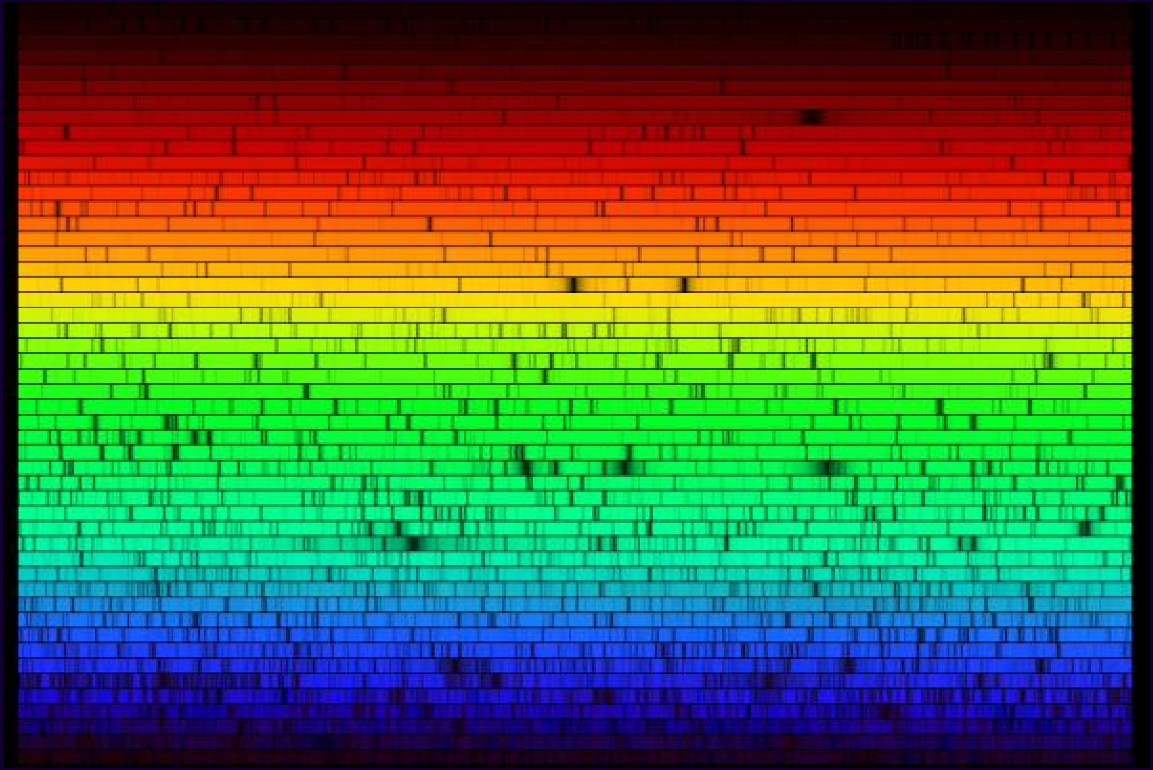
Light and matter

Astronomy 101
Syracuse University, Fall 2022
Walter Freeman

November 1, 2022



Announcements

- Your paper is due Thursday, November 3. If you need an extension, please let us know in advance and tell us why.
- If you have questions about your paper, come to office hours or ask on Discord.

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- If you have questions about your paper, come to office hours or ask on Discord.
- If you are looking for extra help with your paper, bring a draft to office hours or send it to Kiersten Edwards, our writing coach, at `kedwar03@syr.edu` or on Discord.

Announcements

Homework Quiz 5 is Thursday.

The back page of your homework says what's on it, as usual.

Final projects

Your final project in this class is a chance to combine astronomy with something of yourself.

There is a long list of prompts on the course website, but many of you will choose something else – your *own* ideas.

We've had:

- Art projects
- A marching band show
- Musical performances and composition
- Astrophotography
- A video game
- Poetry
- Essays
- A tarot deck
- A constellation map of Middle-earth and a model of the Crown of Elbereth
- ...

Final projects

The best final projects for this class are ones that combine astronomy (or science generally) with one of your other interests or talents.

As with the paper in this class, we do "open-ended" grading for these (you can earn more than 100% for exemplary or inspiring work).

Many students in the past have found this opportunity to be inspiring and rewarding – we hope you will too!

Chemistry: all I want you to know

- Electrons occupy certain **energy levels**
- The particular energies that these levels have is **unique** to particular elements: hydrogen has different allowed energies than mercury or neon or sodium etc.
- An atom can absorb a photon and jump up to a higher level, conserving energy
- ... an atom in a higher level can emit photons, jumping back down, conserving energy.
- "Nature does not make change"

... that's it. :)

Work on your in-class exercise.

If you need a copy, we have extras.

Emission spectra

Every chemical element has a unique *spectrum*: the colors of light that it can emit and absorb.

Other colors simply pass through.

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

Suppose I put a 5000 K object behind a cloud of gas with energy levels at 0, 3, and 5 eV. What does the 5000 K object do?

A: Emit light of a broad range of wavelengths

B: Absorb light of a broad range of wavelengths

C: Emit light made of 3 and 5 eV photons

D: Absorb light made of 3 and 5 eV photons

Suppose I put a 5000 K object behind a cloud of gas with energy levels at 0, 3, and 5 eV. What could this cloud of gas do?

A: Emit light of a broad range of wavelengths

B: Absorb light of a broad range of wavelengths

C: Absorb photons with at least 2 eV of energy

D: Absorb photons of 2, 3 and 5 eV, and allow the rest to pass

Suppose I put a 5000 K object behind a cloud of gas with energy levels at 0, 3, and 5 eV, and then look at the energies of the photons that come out the other side.

A: Photons with energy 3 and 5 eV

B: Photons with energy 2, 3, and 5 eV

C: Photons of a wide range of energies, *except* 3 and 5 eV

D: Photons of a wide range of energies, *except* 2, 3, and 5 eV

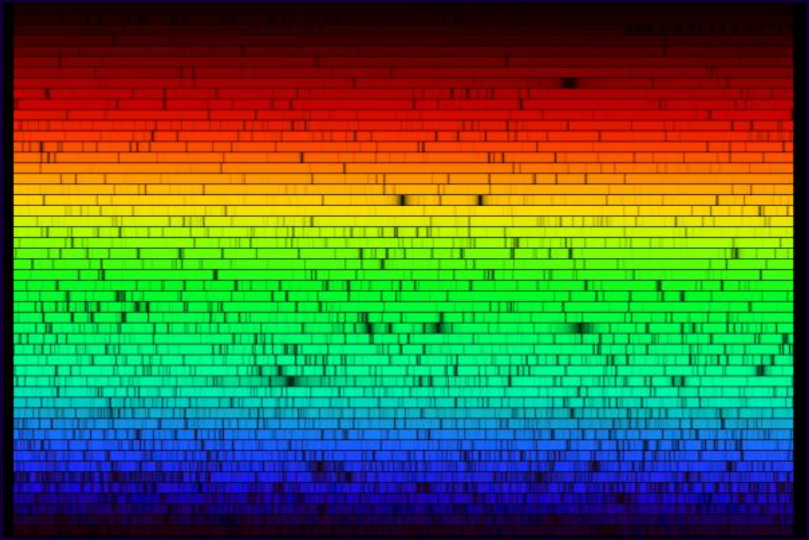
Suppose I put a 5000 K object behind a cloud of gas with energy levels at 0, 3, and 5 eV, and then separate its light by color. (Assume that I am a bird and can see ultraviolet light.) What would I see?

A: Only two bright lines

B: Only three bright lines

C: A solid band of color, but with two dark lines

D: A solid band of color, but with three dark lines



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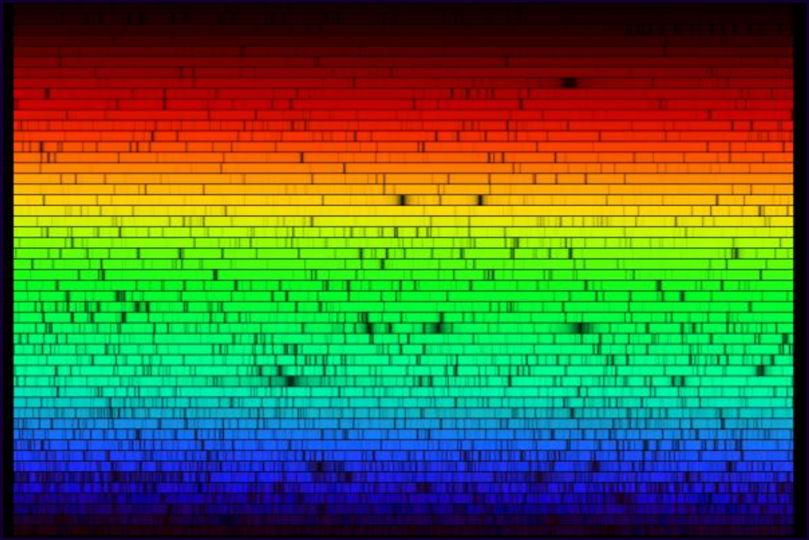

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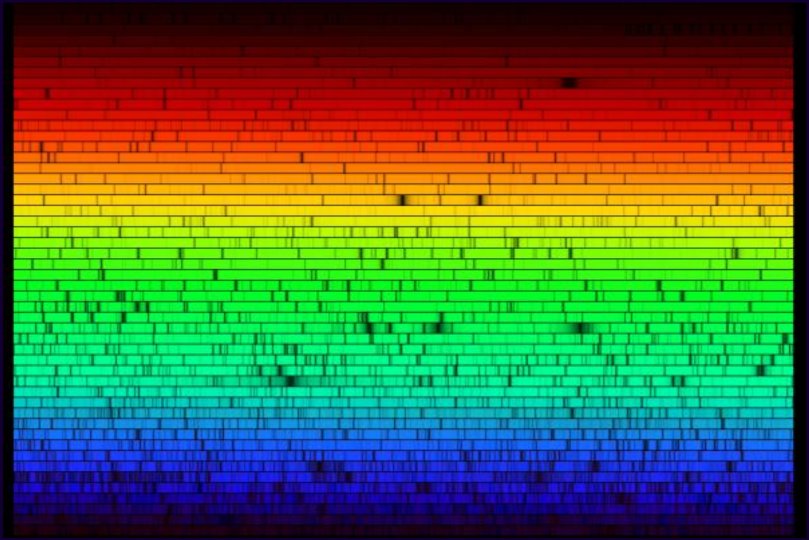
- The gases in the cooler atmosphere absorb light of their particular wavelengths



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This picture tells us what's in the Sun!

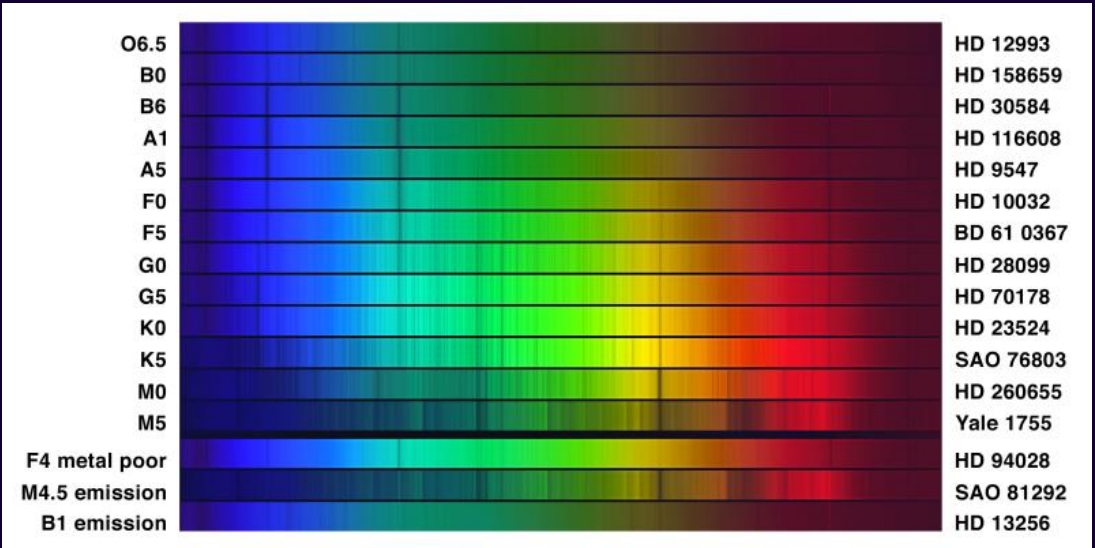
You discover lines in the solar spectrum that don't correspond to any known element. What do you conclude?

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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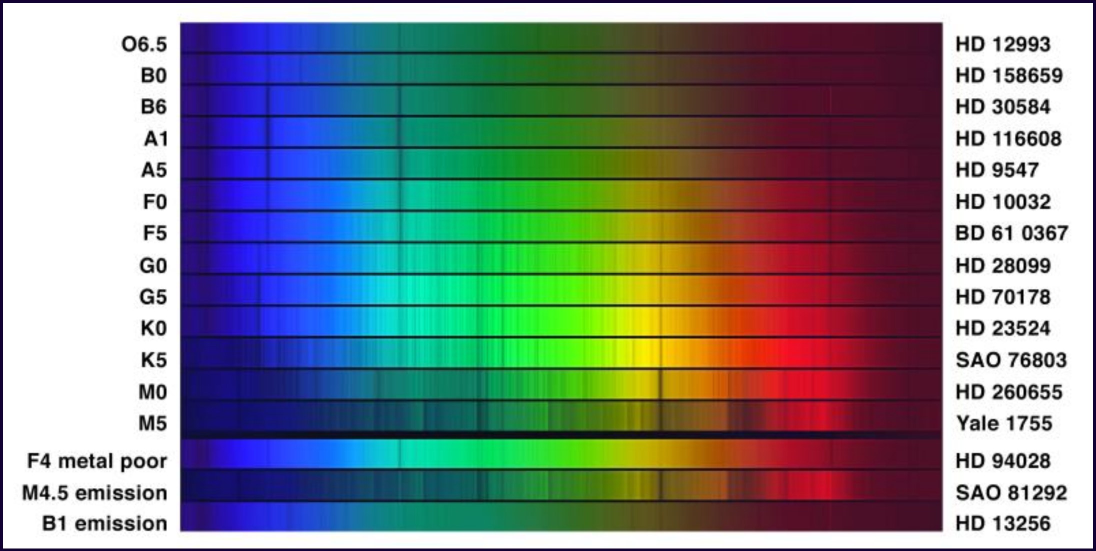

All the stars are made of the same stuff – the same stuff as we are.

“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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- 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.)