Are we alone in the Universe?

Class 7.

Emrah Kalemci

ekalemci@sabanciuniv.edu

Office: FENS G018

Sabancı University, FENS

Sabancı Üniversitesi LİSE YAZ OKULU

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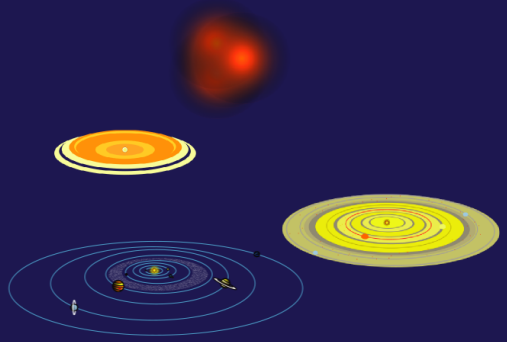
Our Map:

What are there in the Universe?
Scales involved in describing Universe

Our planet and Solar system

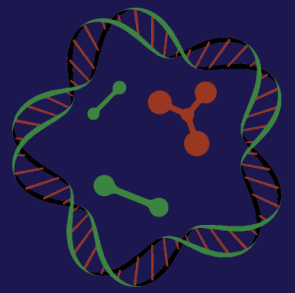


How did the Solar system form?
Is it unique?

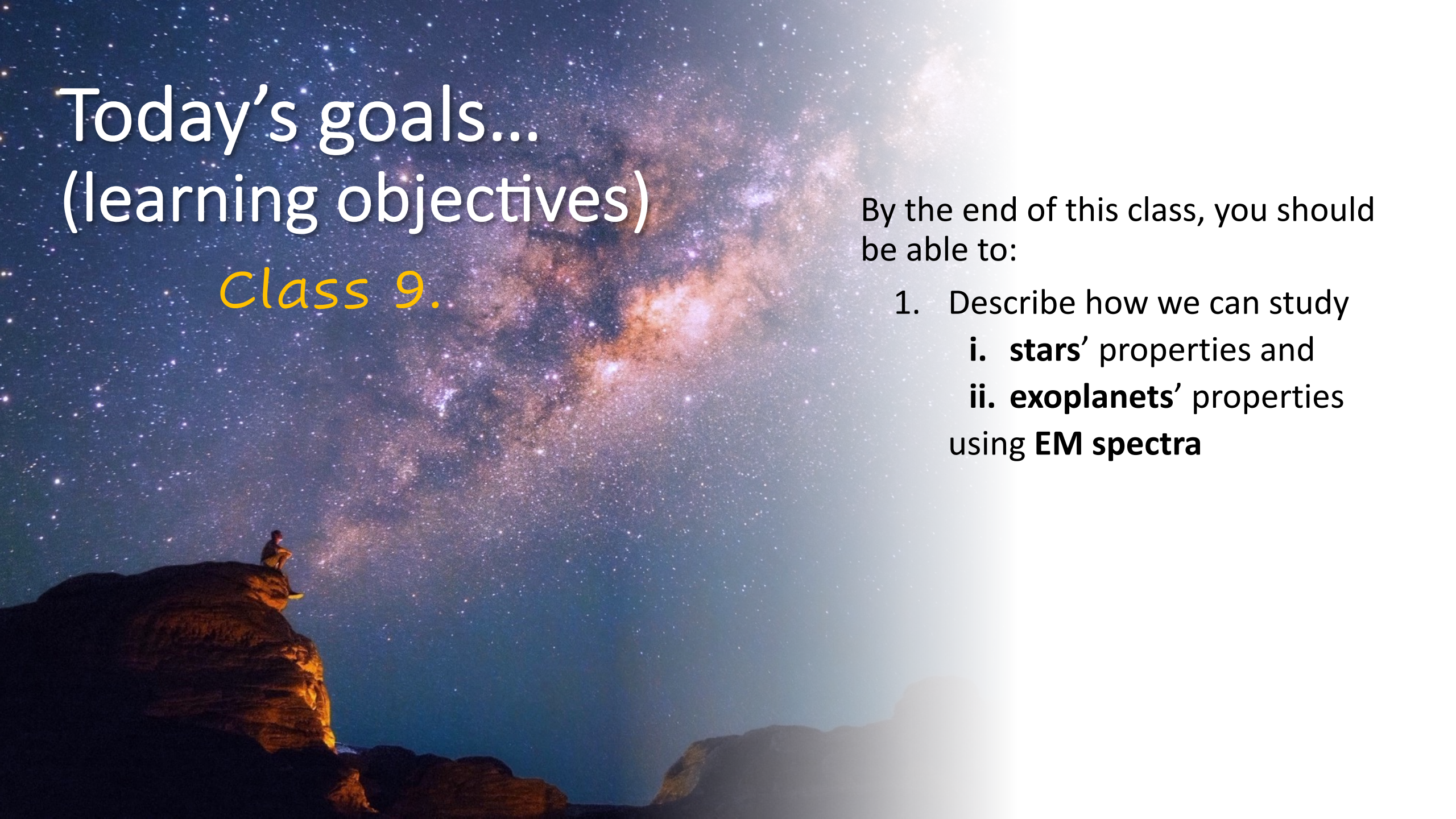
Are we alone in the universe?

What form of life would you look for and how? Possibility of life on other planets.

How can we look for ET life?
Atom and EM spectrum.



What is life?
How did life on Earth begin? Building blocks of life, first form of life on Earth.



Today's goals… (learning objectives)

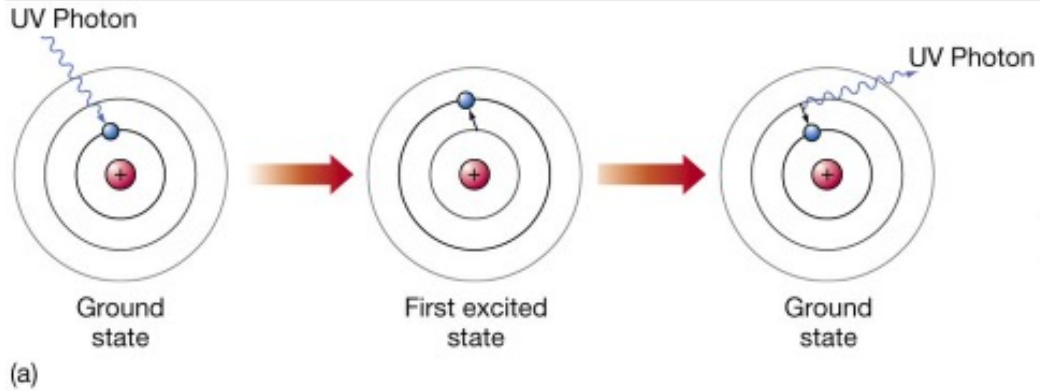
Class 9.

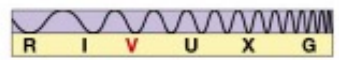
By the end of this class, you should be able to:

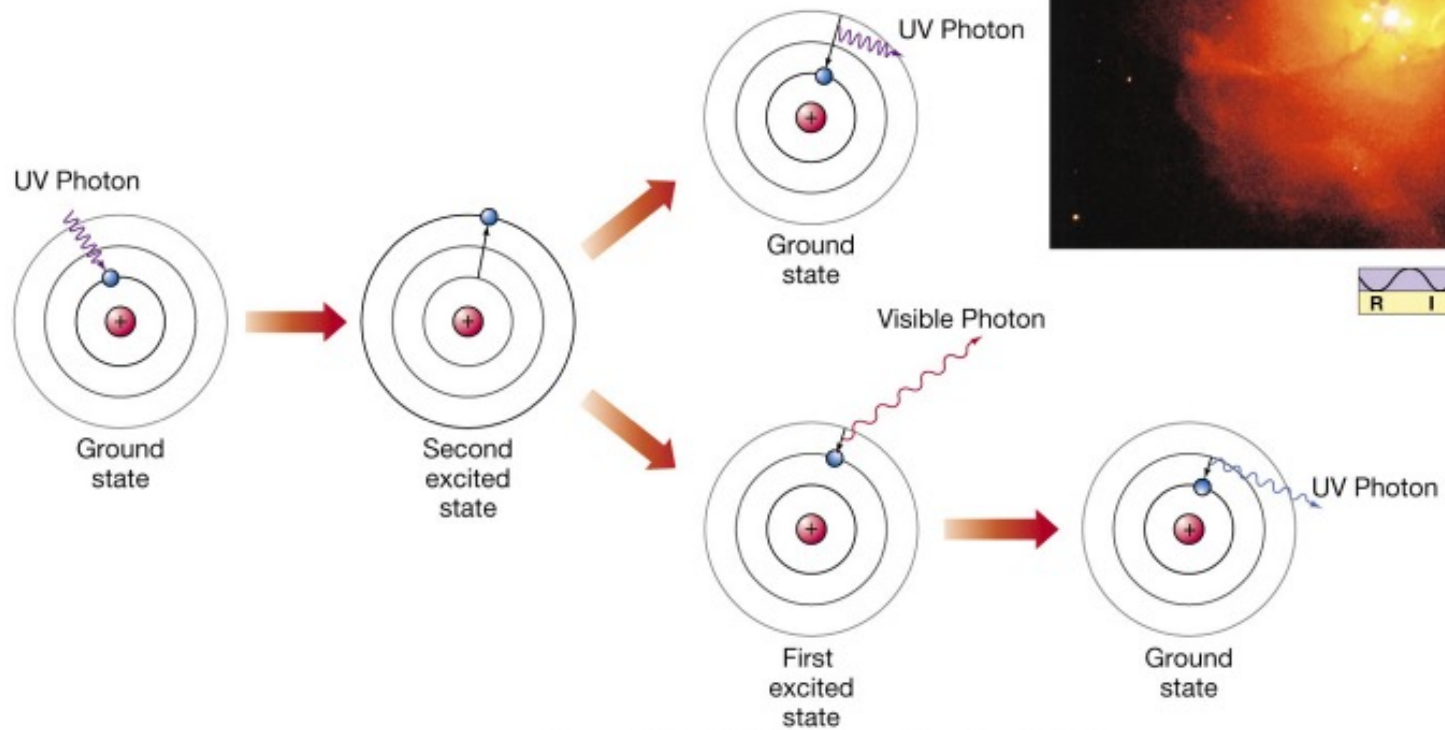
1. Describe how we can study
   i. **stars**' properties and
   ii. **exoplanets**' properties

   using **EM spectra**

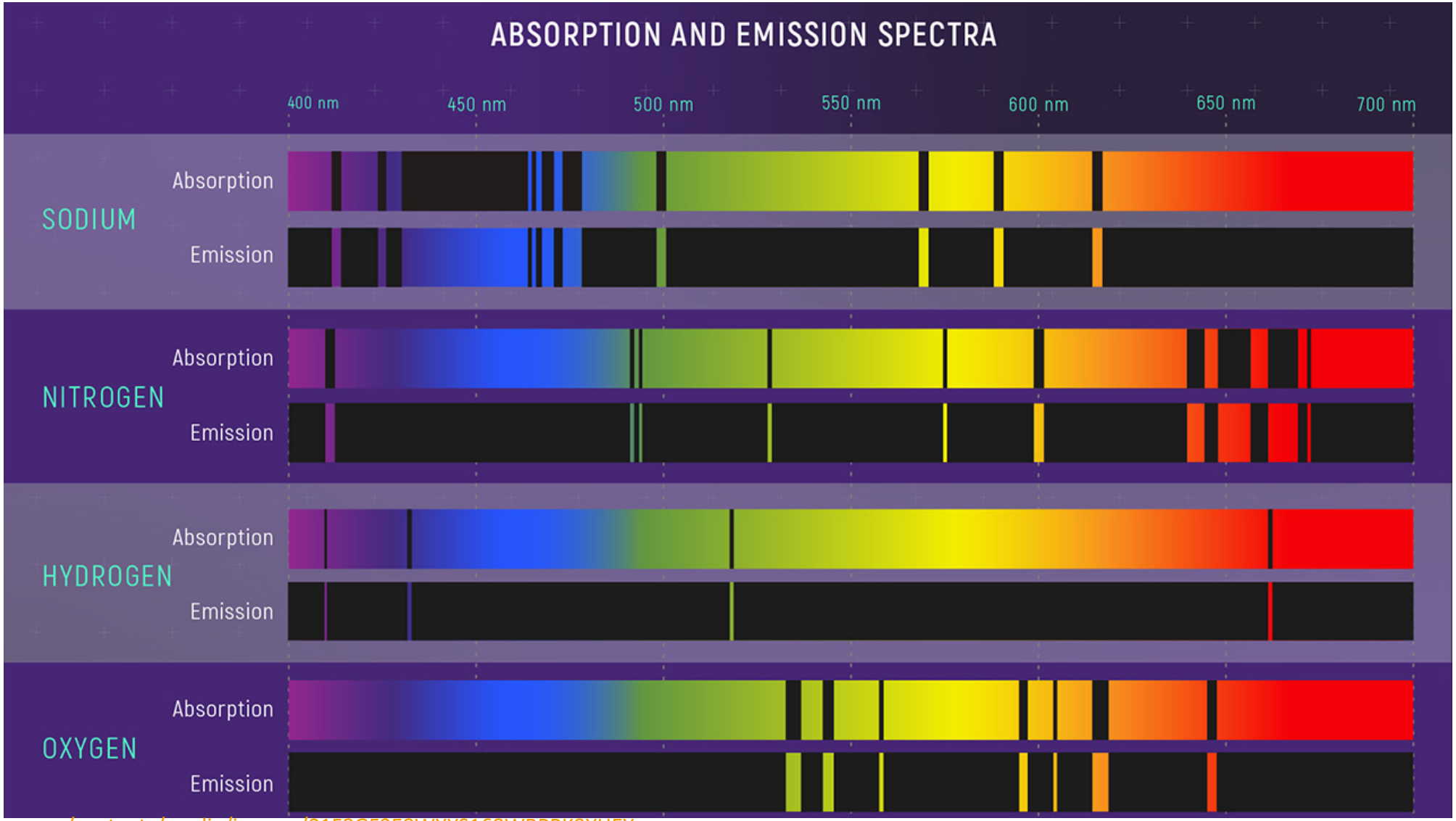
Atomic Excitation



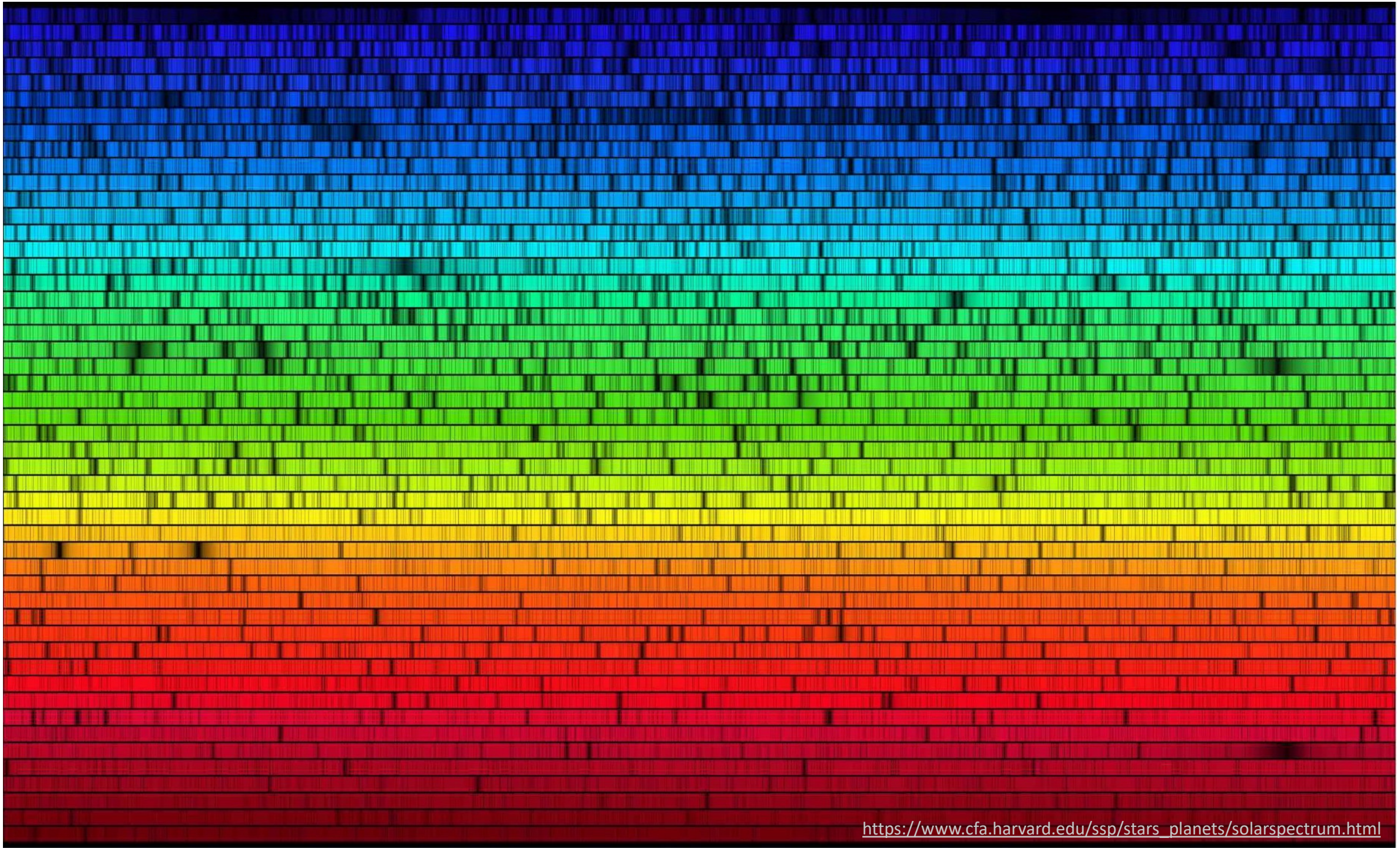




Spectral lines = Fingerprints of elements



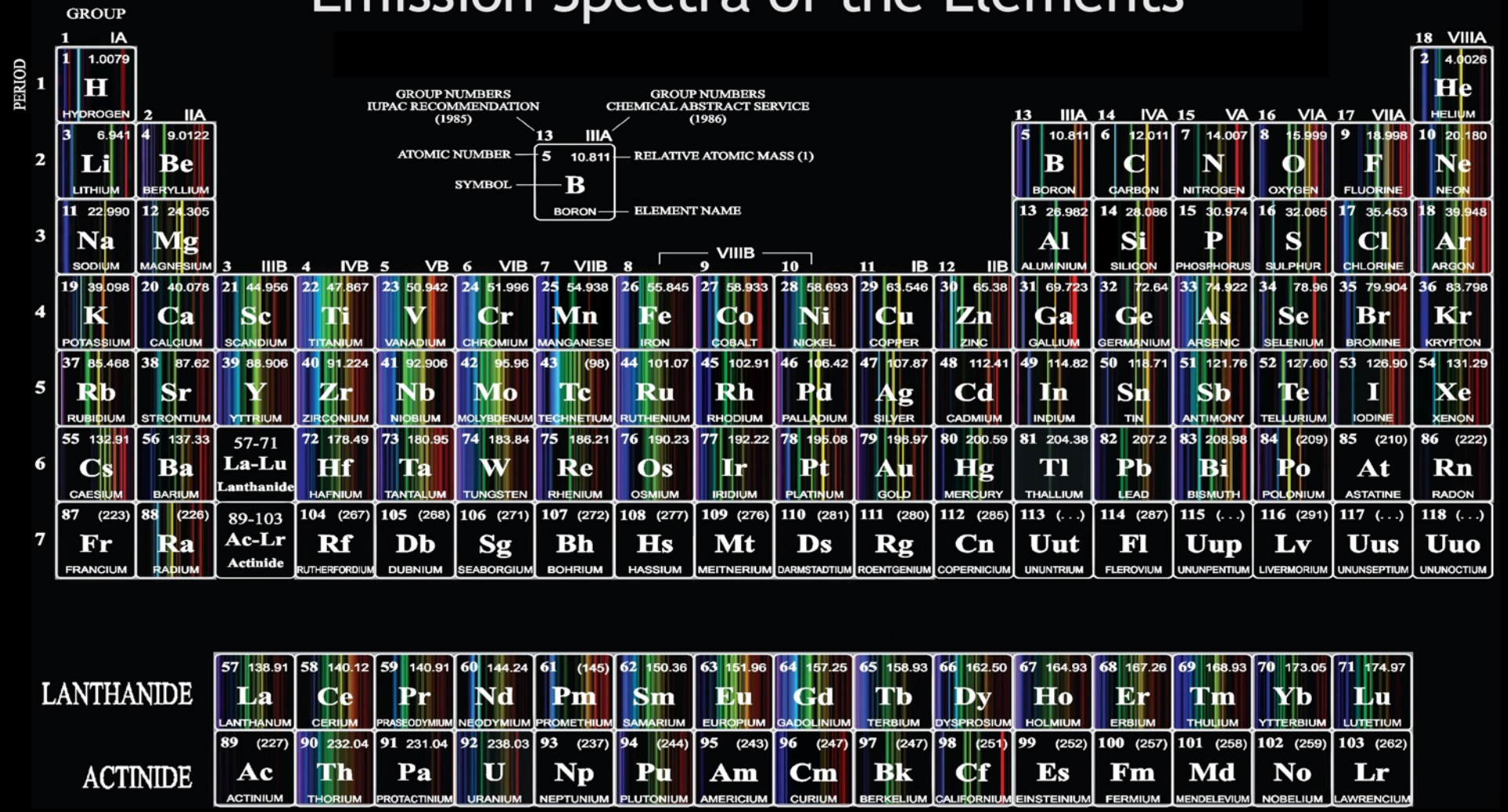
https://webbtelescope.org/contents/media/images/01F8GF9E8WXYS168WRPPK9YHEY


https://www.cfa.harvard.edu/ssp/stars_planets/solarspectrum.html

QUANTUM for FUN, Literally….

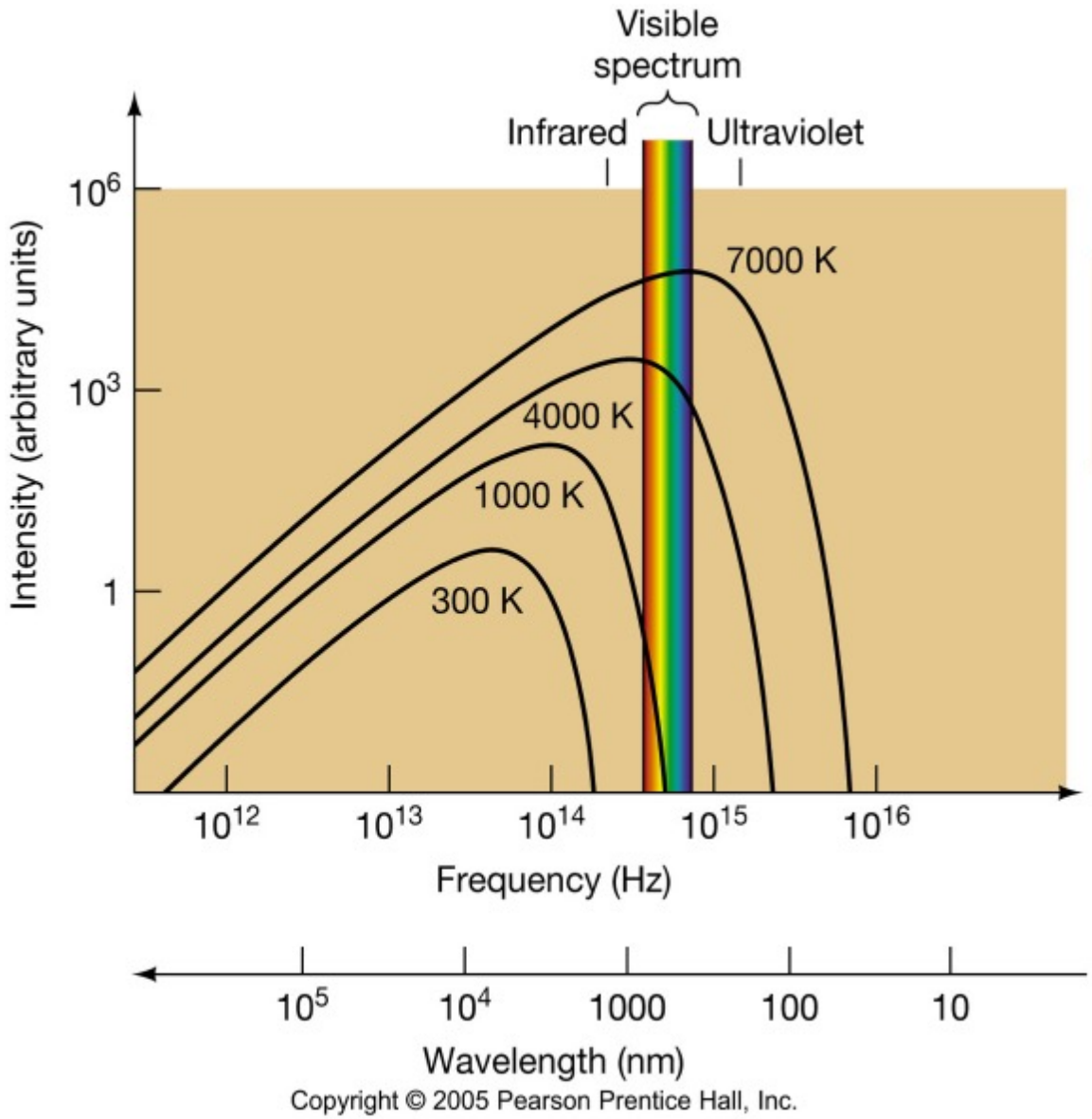
PERIODIC TABLE OF THE ELEMENTS

Emission Spectra of the Elements



https://i.redd.it/xk8rxdh0j06y.jpg

Blackbody Radiation



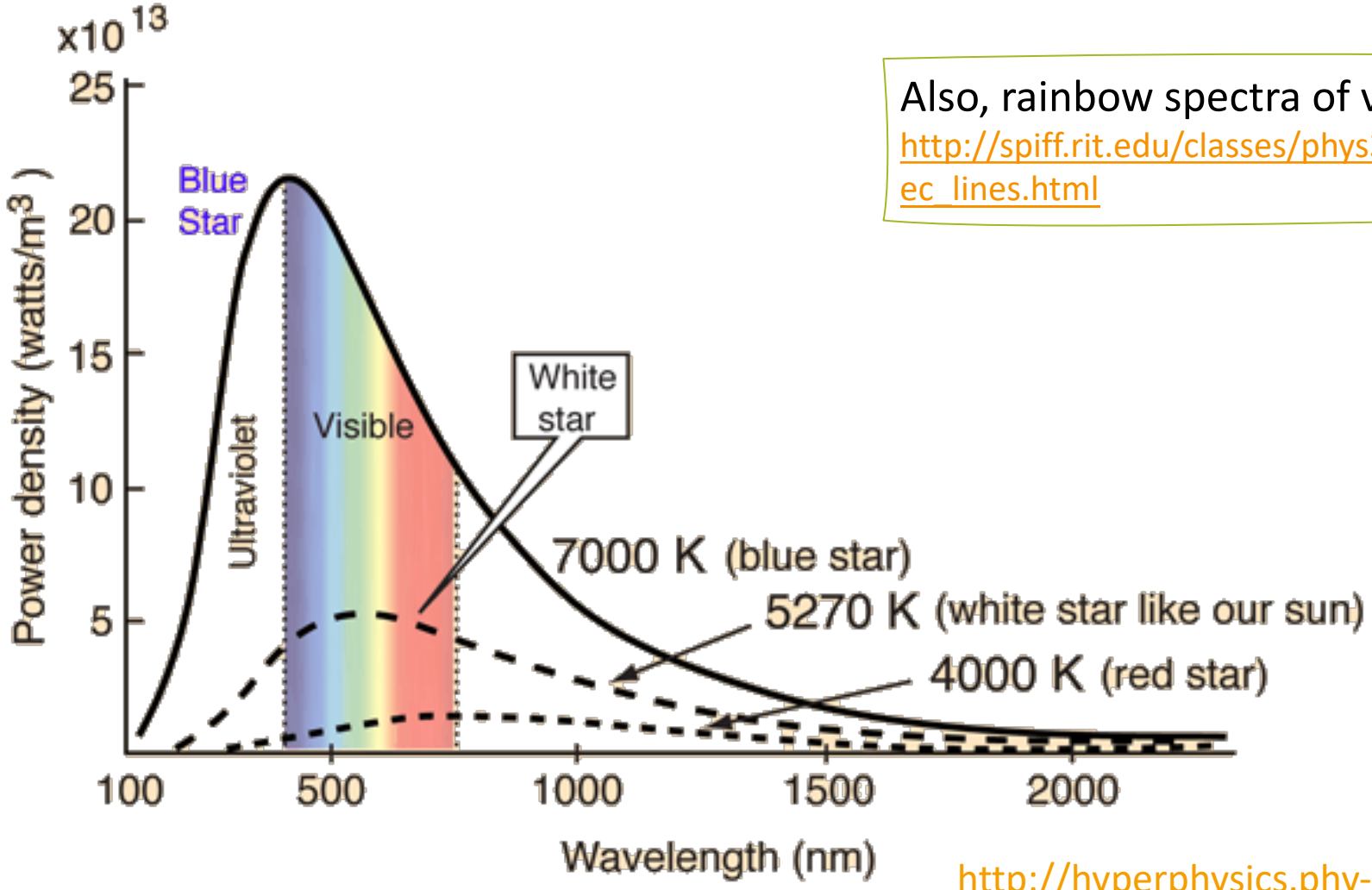
Black body Spectra

Wien's Law

$\lambda_{max} = 0.29 \text{ cm} / T$

Black body radiation has a **continuous spectrum**

Star's Spectrum: Blackbody Spectrum



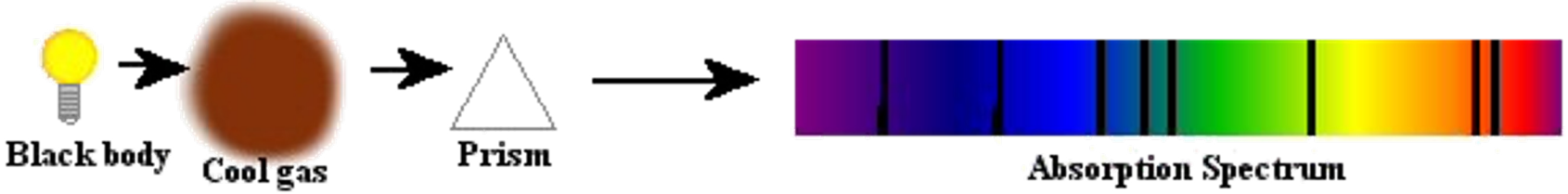
Also, rainbow spectra of various temperatures: http://spiff.rit.edu/classes/phys301/lectures/spec_lines/spec_lines.html

http://hyperphysics.phy-astr.gsu.edu/hbase/wien.html

Different Types of Spectra

like a complete rainbow, with no gaps and breaks in it (continuous spectrum).

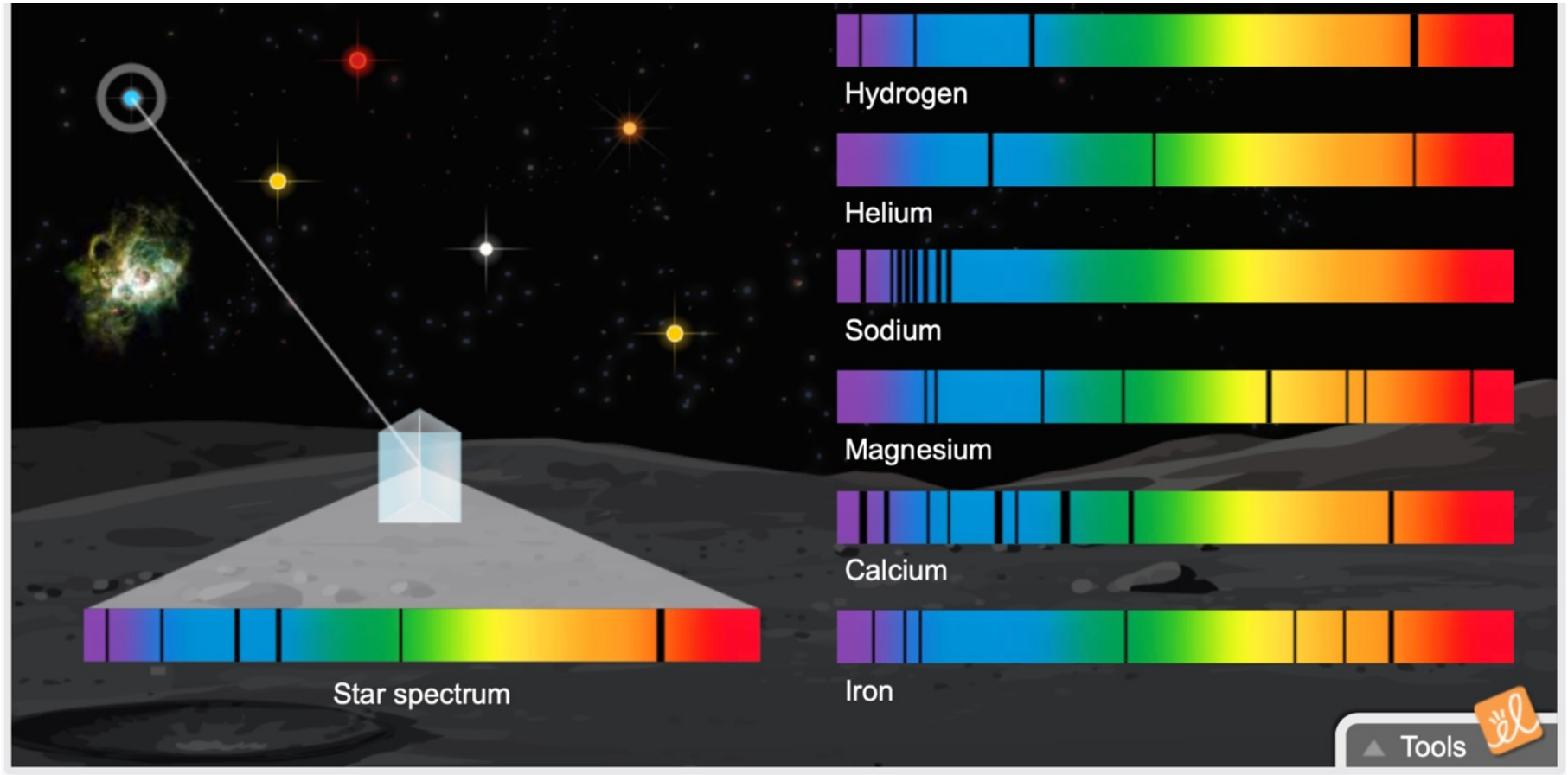
Discrete bright lines on a dark background.
There are often a lot of dark space between the lines.



Dark lines (certain wavelengths is absorbed) on a bright background.

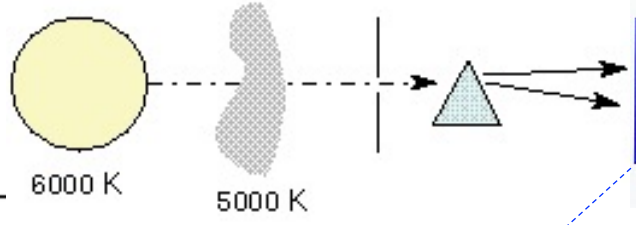
Absorption Spectrum of a Star

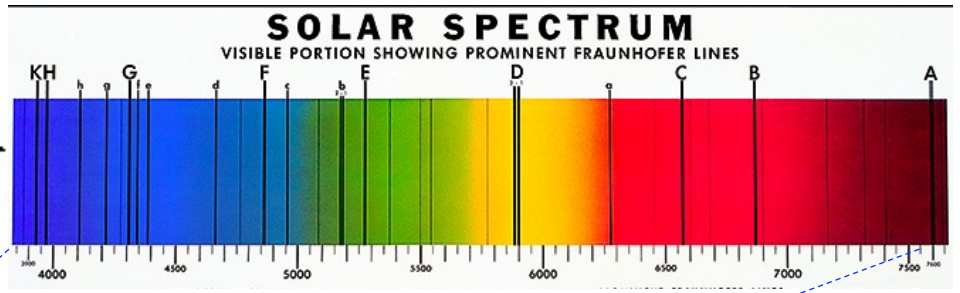
Question: Which elements are in the atmosphere of this star?

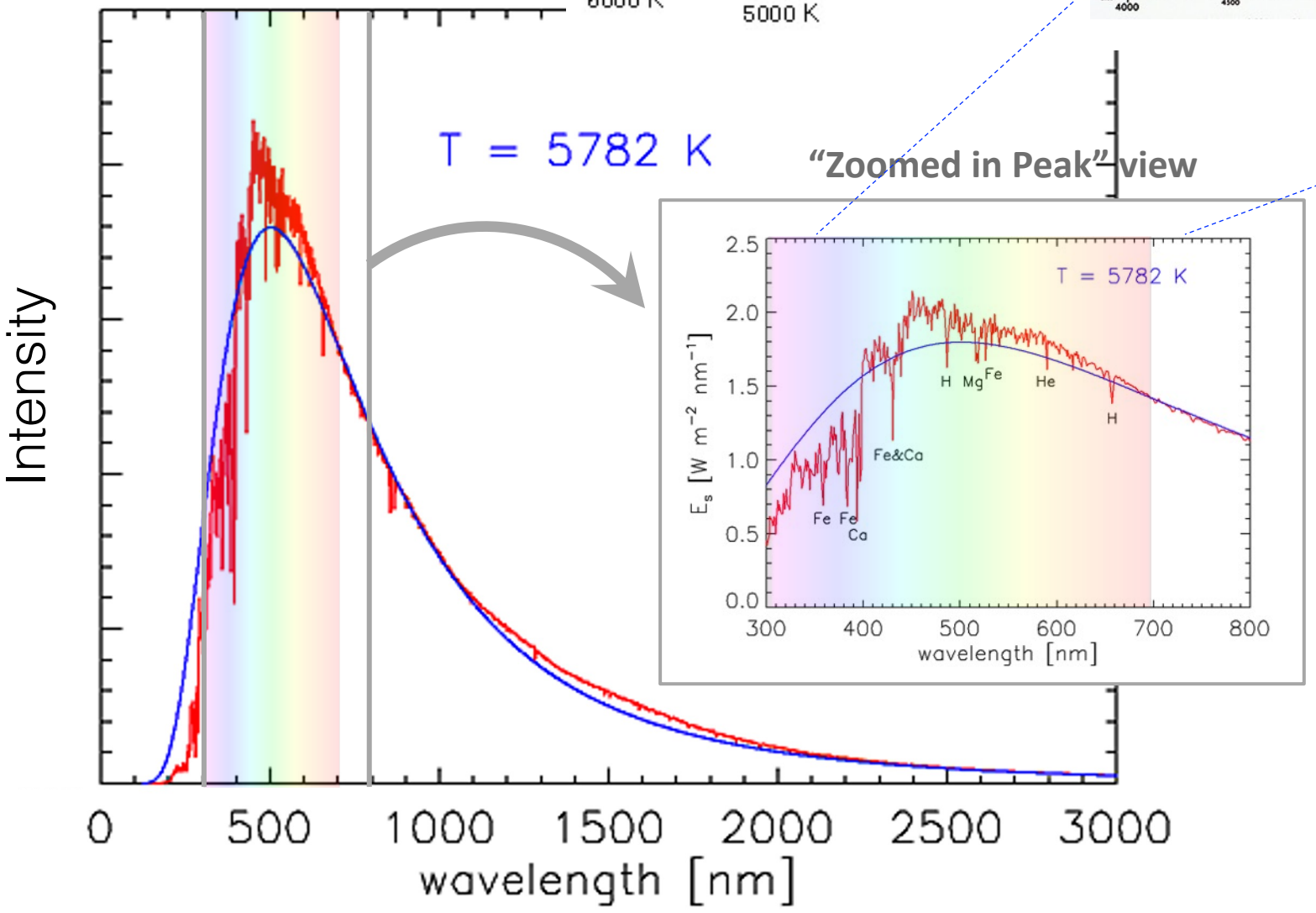


https://www.explorelearning.com/index.cfm?method=cResource.dspDetail&resourceID=558

Actual Solar Spectrum







"Zoomed in Peak" view

Using Spectrum, we can learn:

- presence of certain elements
- temperature, T
  $\lambda_{peak} = (2.9 \times 10^{-3}\ \text{m·K})/T$
- source of the EM emission
- (orbital) speeds involved

Absorption due to:

- atoms → thin lines
- molecules → broad lines