Rainbows, Stars & Atoms

Quantum 4 Kids

Of All Ages !!!

The size of things &
How they are related

A special presentation for the

THE RESERVE
AT RANCHO MISSION VIEJO

Image credit: NASA, ESA, CSA, and STScI

Donn Silberman

Optics Institute of Southern California

http://oisc.net

Introduction

Who am I?

And Why am I here talking to you?

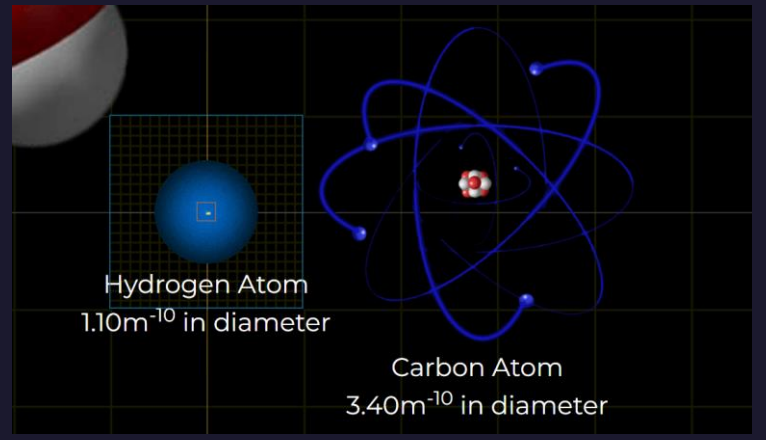
- **QuantumOpticsAge –**
- **https://donn601.wixsite.com/opticsage**

Society of Physics Students

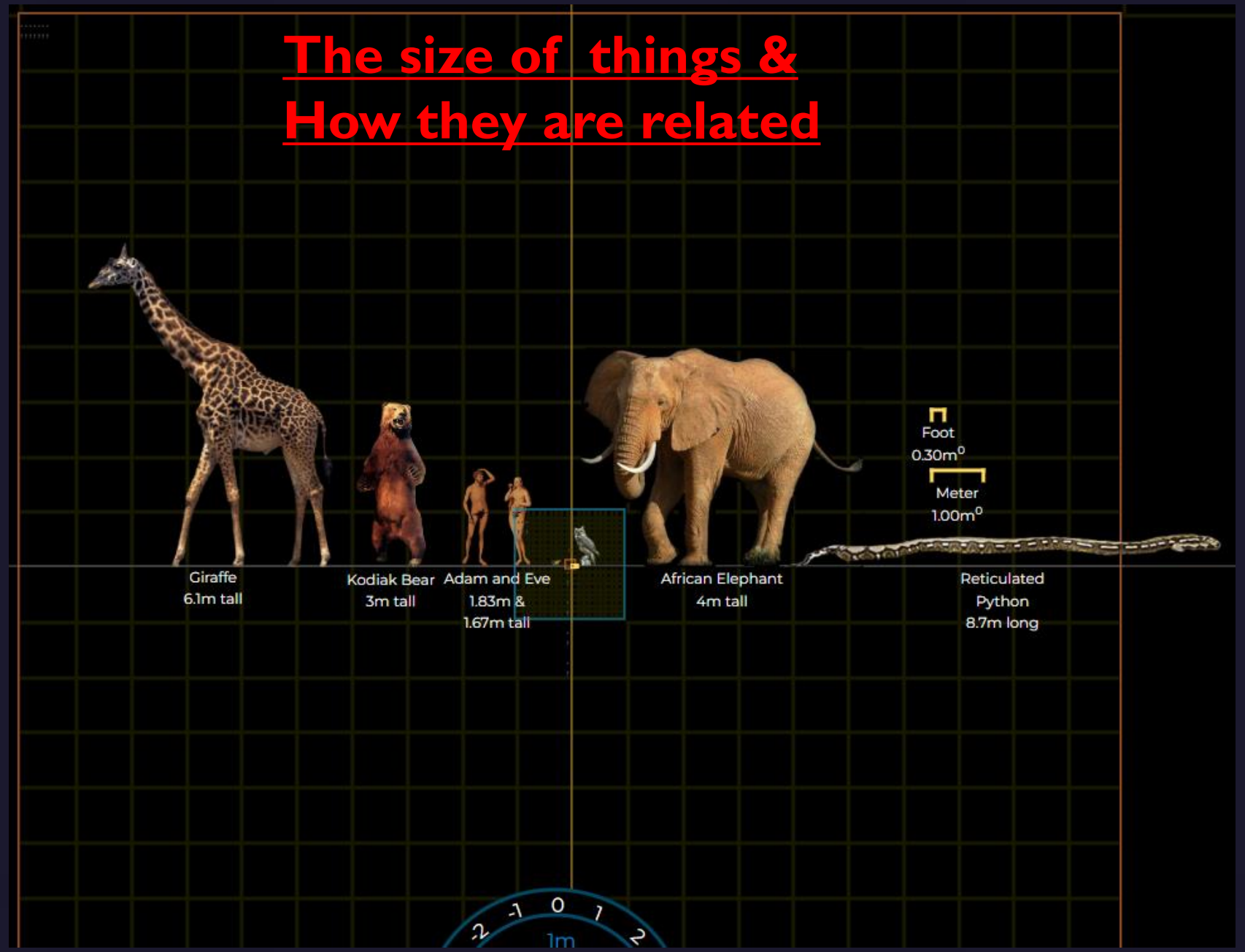
Topics for Today

1. The size of things and how they relate.
2. What are Rainbows & why should you care?
3. What are stars & how do we know?
4. How do we know about atoms?
5. How do we use this information?
6. On-line and In-Person Resources
7. Questions & Answers

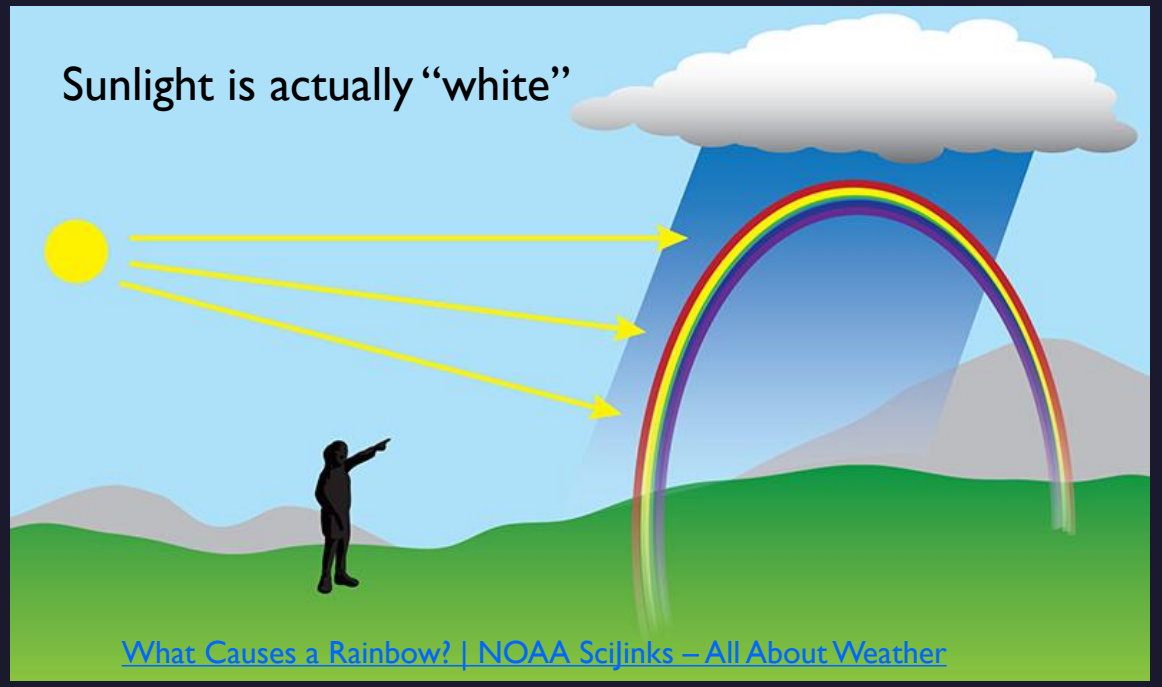
Image credit: NASA, ESA, CSA, and STScI



Magnifying The Universe: Interactive Journey from the Smallest Particles to the Largest Galaxies | Academic Influence



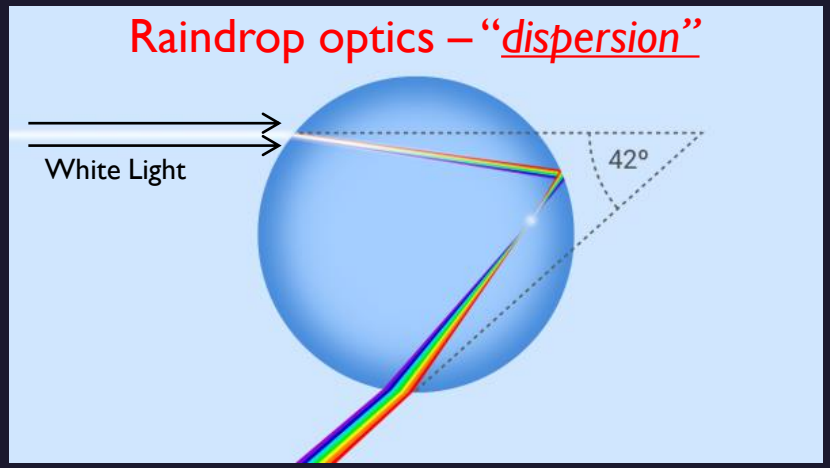
What are Rainbows?



Raindrops + Sun***light*** = Rainbows

But why should you care ???

All modern civilization is based on what we learned about rainbows !!!
We'll get to the details when we talk about stars & atoms !!!



You can make your own rainbows !!

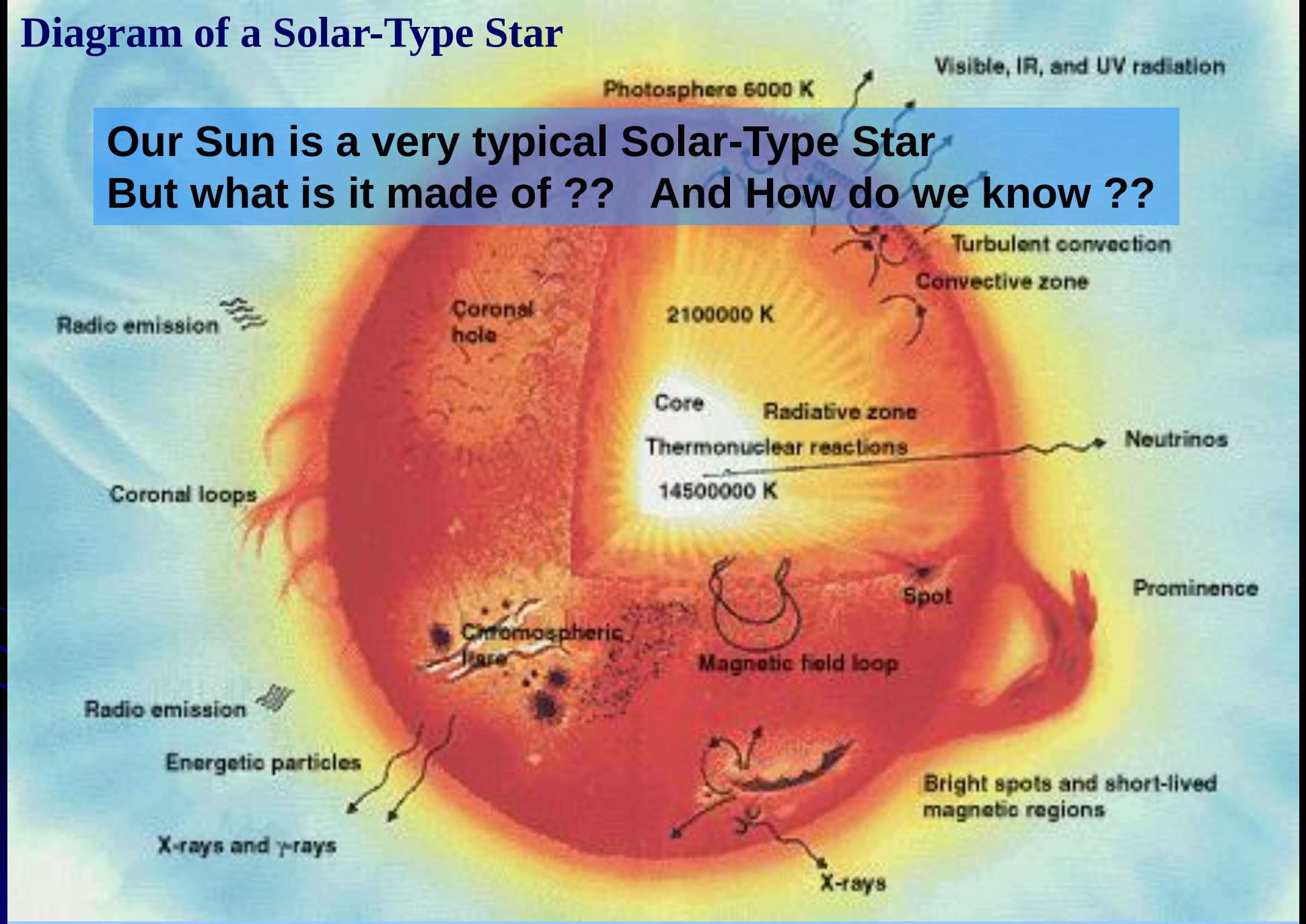
Water sprayed from a garden hose can produce a rainbow. | U.S. Geological Survey (usgs.gov)

Rainbows (Water and Light) | U.S. Geological Survey (usgs.gov)

Twinkle, Twinkle, Little Star ...
How I Wonder What You Are ...

- Did you ever wonder what stars are?
- Did you notice that stars have different colors?
  - The different colors indicate different:
    - Temperatures
    - Sizes
    - Masses
- Do you know where the nearest star is located?

Diagram of a Solar-Type Star



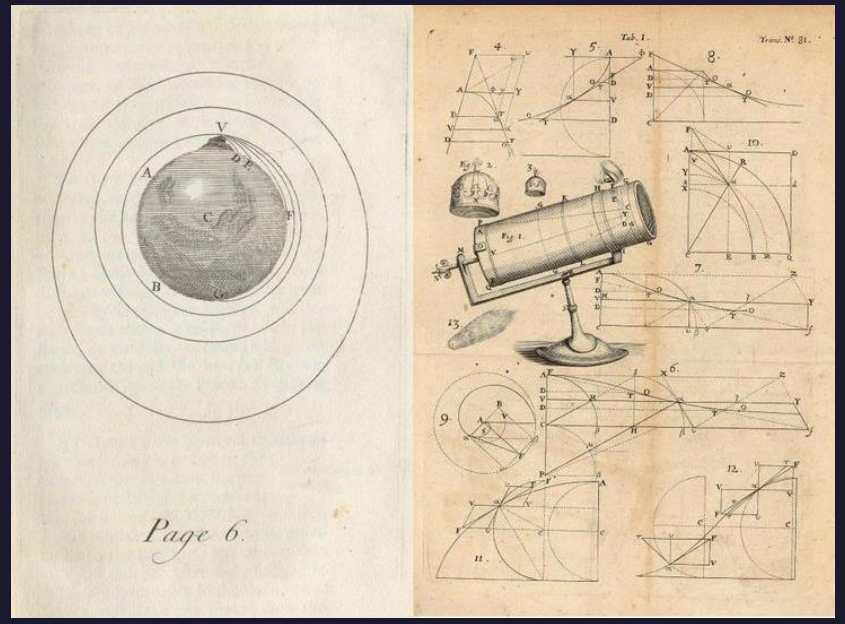
Our Sun is a very typical Solar-Type Star
But what is it made of ?? And How do we know ??

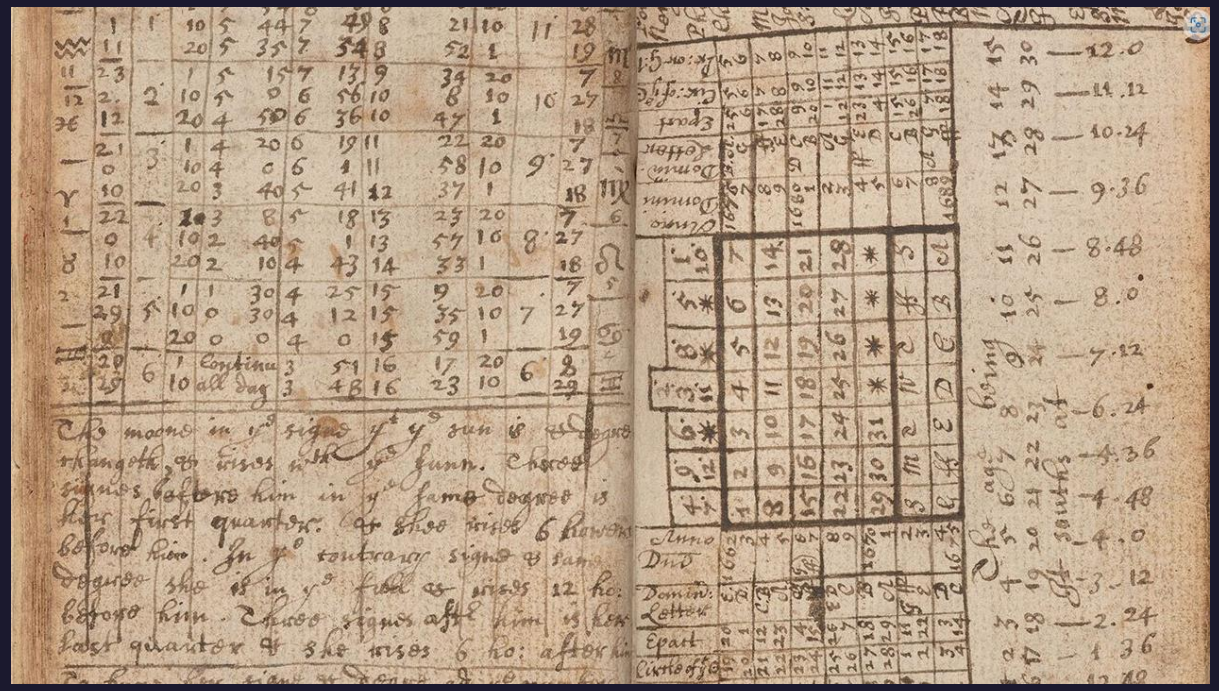
What are the Stars ?
And how do we know?

Isaac Newton and his reflecting telescope (1672).
(350 years ago)

Pages from Newton's notebook recording his astronomical observations.

The prism separates the white light into the colors of the rainbow. (Just like raindrops.)
Isaac Newton - Wikipedia



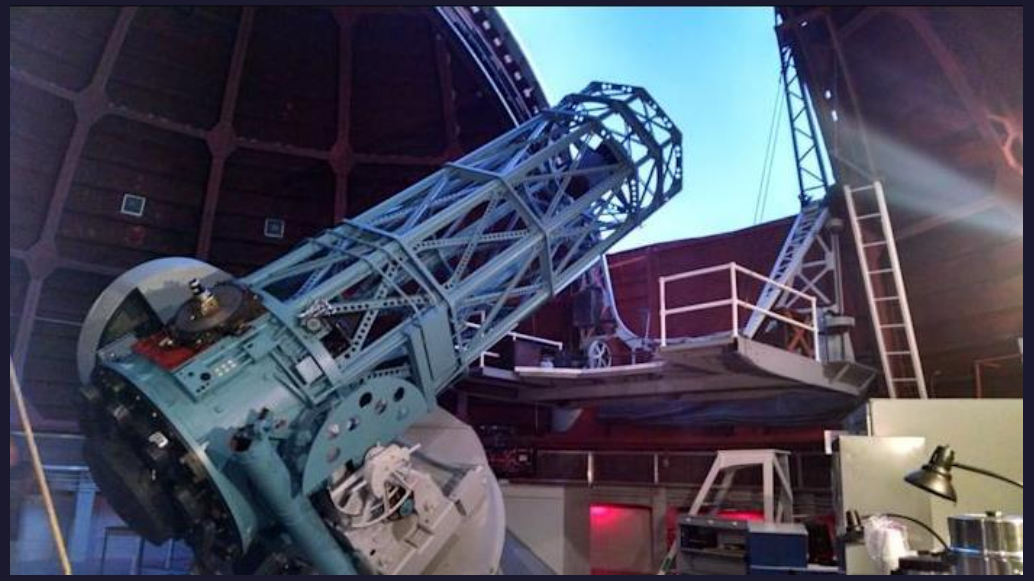


Recording observations (data) by hand in a notebook.

Edwin Hubble

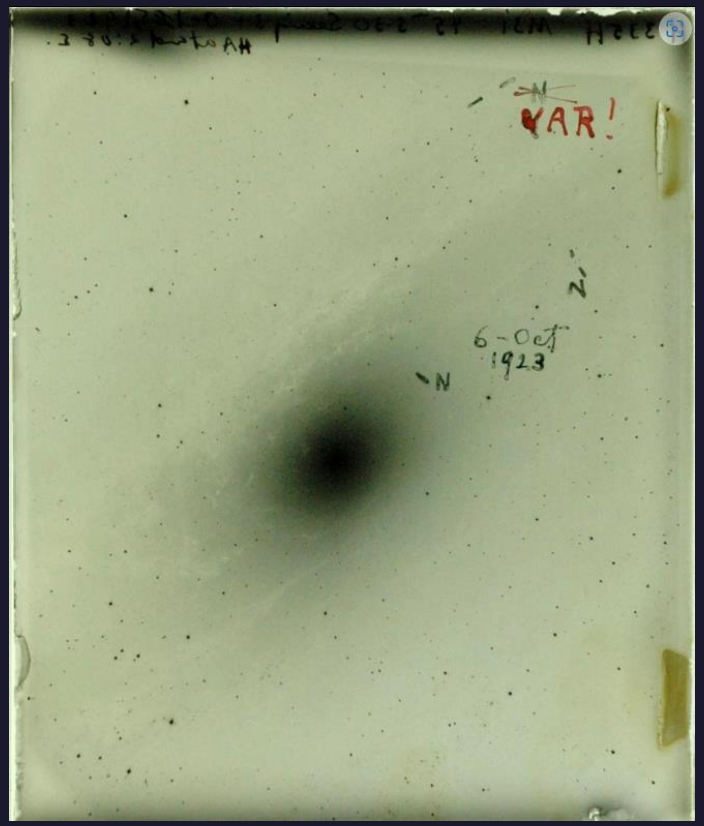
Doing research with the 100" Hooker Telescope (1917 – 1922 and beyond.) {250 yrs after Newton}
Using photographic glass plates to record the images of the stars & galaxies.
Also documenting observations in notebooks and on the photographs.

A young ***Edwin Hubble*** at Mount Wilson's 100-inch telescope circa 1922, ready to make history.
Hubble's Other Telescope And The Day It Rocked Our World | KERA News



Mt. Wilson Observatory – 100" Hooker Telescope
Completed in Nov. 1917 in the Los Angeles area.
Mount Wilson Observatory | Building the 100-inch Telescope (mtwilson.edu)

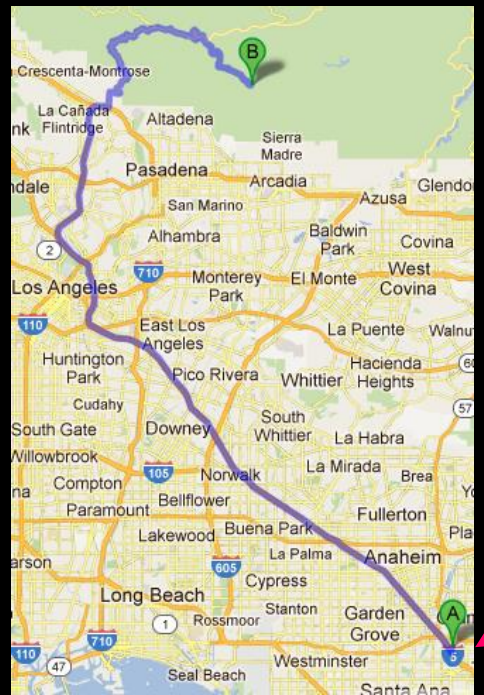
You can look through this telescope now
Open to the public – by appointment only



This glass side of a photographic plate shows where Hubble marked novae. The red VAR! in the upper right corner marks his discovery of the first Cepheid variable star — a star that told him the **Andromeda Galaxy** isn't part of our Milky Way.
Courtesy of the Carnegie Observatories

Mt. Palomar Observatory – 200” Hale Telescope

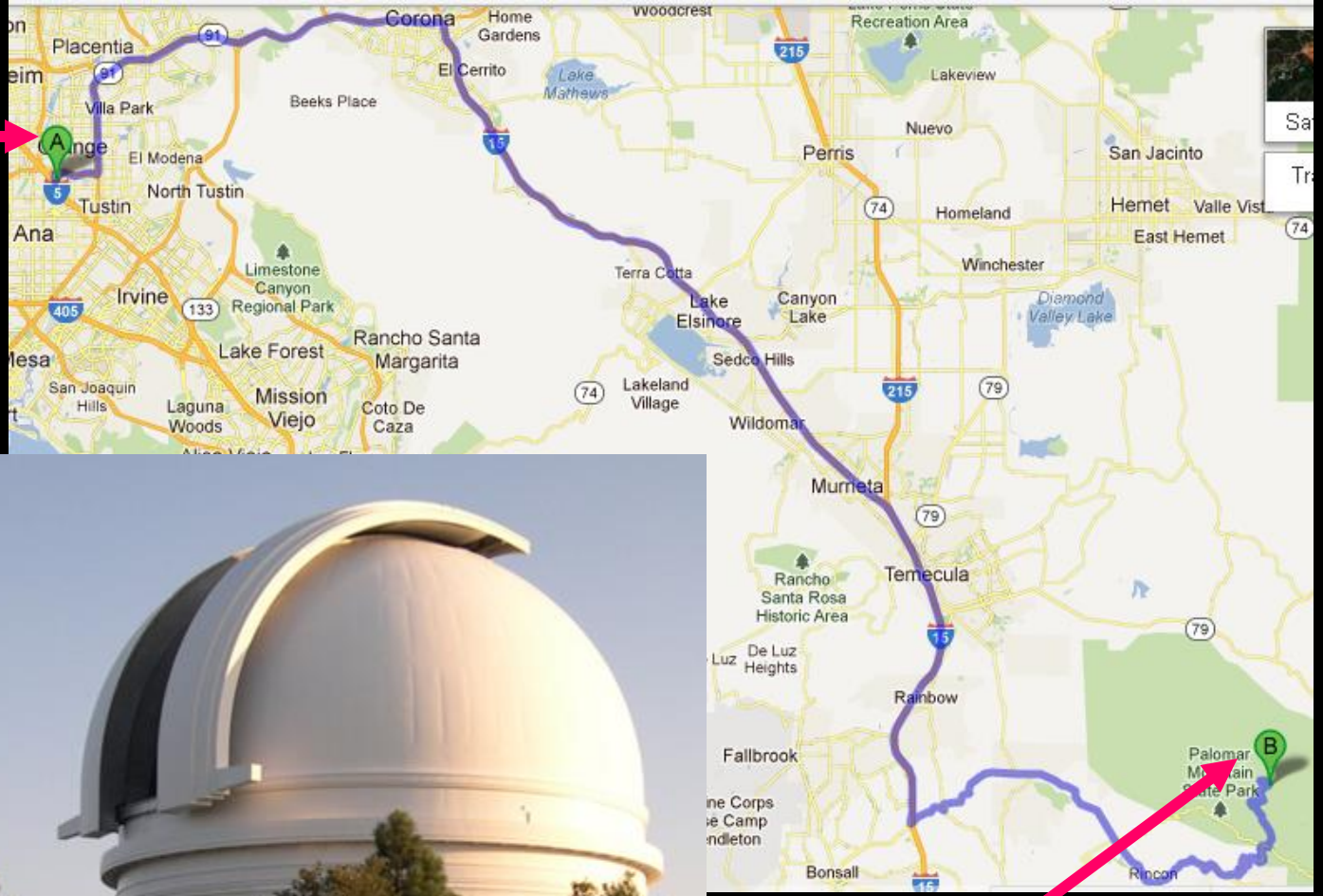
Historic image of the **Andromeda Galaxy** (M31) taken by Edwin Hubble with the 200” Hale Telescope. Feb. 5, 1924



1.5+ hour drive

DISCOVERY SCIENCE CENTER

DISCOVERY SCIENCE CENTER



~3-hour drive

The Hubble Space Telescope

[Messier 31 (**The Andromeda Galaxy**) | NASA]

84 years after Hubble's photo on the 200" Hale Telescope

Hubble's M31 mosaic image, taken by the Panchromatic Hubble Andromeda Treasury (PHAT) program, is shown in context with a ground-based image of the entire galaxy. Despite the size of Hubble's massive mosaic, it does not span even half of the galaxy.

Credits: NASA, ESA and Z. Levay (STScI/AURA); PHAT Mosaic: NASA, ESA, J. Dalcanton, B.F. Williams, L.C. Johnson (University of Washington), the PHAT team and R. Gendler; Ground-based Background Image of M31 (c) 2008 R. Gendler, used with permission

M31

Not taken with a photographic plate.

More like the camera in your cell phone !!!

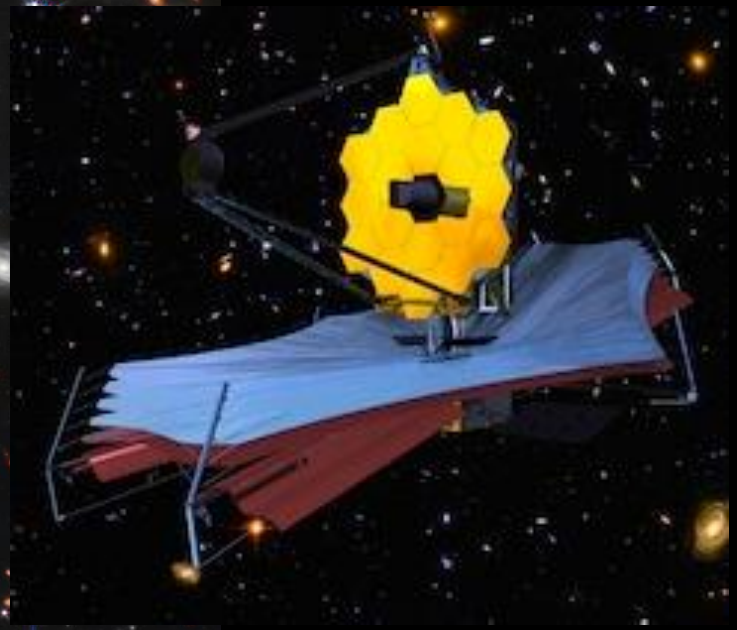
HST
PHAT

Compared to the ground-based telescope image

DSS and R. Gendler

[NASA released the James Webb Space Telescope's first color images. They're awesome. - Vox]

The Hubble Space Telescope



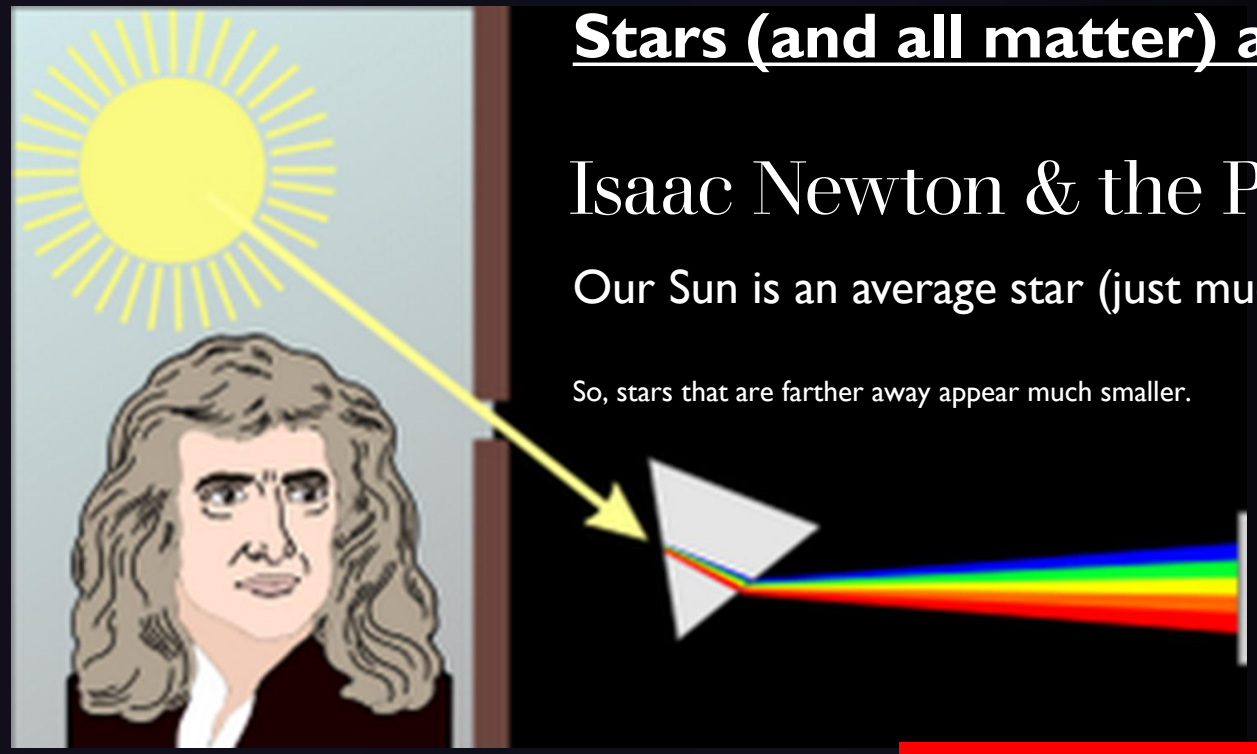
James Webb Space Telescope

"What makes this image so mind-blowing is how small it is, and how large it is, at the same time.

It's small in the sense that this image represents only a teensy tiny portion of the night sky. Imagine you are holding out a grain of sand at arm's length.
The area of sky that grain covers — that's the size of the area captured in the above image.

But it's huge in the sense that nearly every object in this image is a galaxy (besides the bright spiky starbursts, which are stars in the foreground). Think about that: In every pinprick of sky, there are thousands and thousands of galaxies, at least."

Stars (and all matter) are made of **ATOMS**

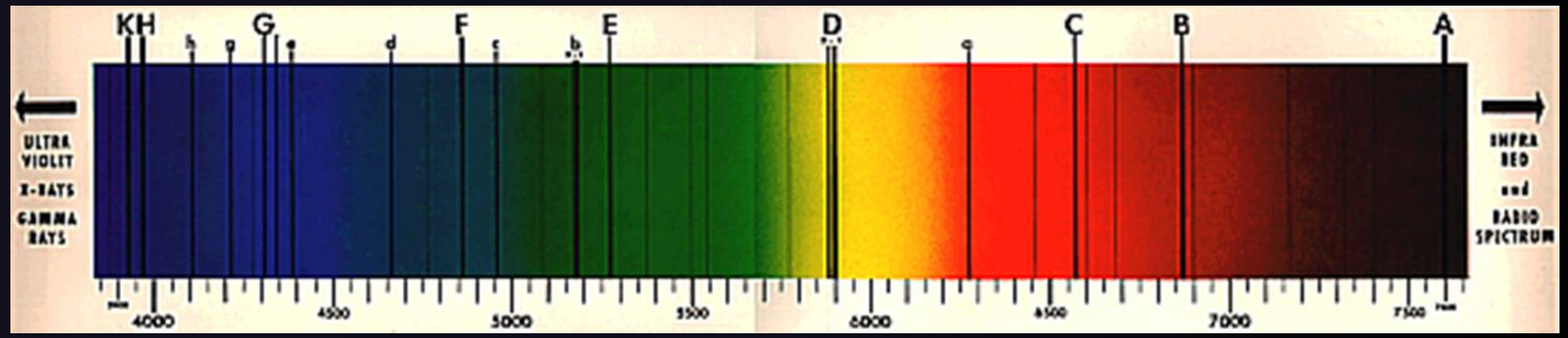


Isaac Newton & the Prism

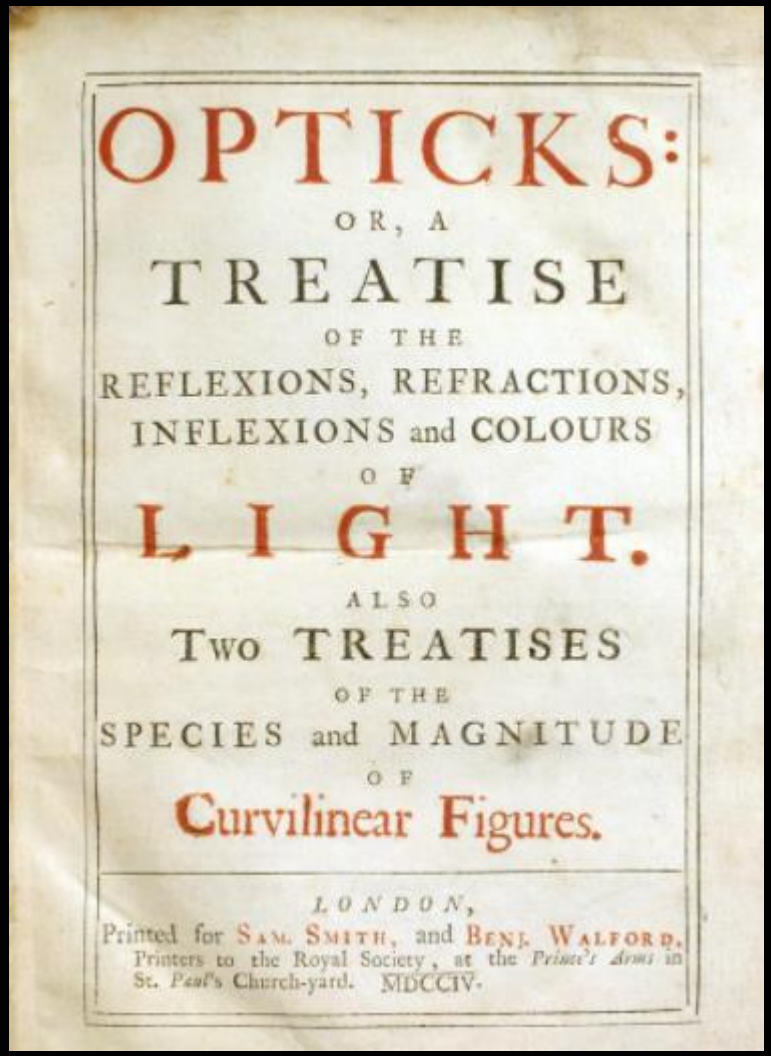
Our Sun is an average star (just much closer to earth)

So, stars that are farther away appear much smaller.

The Solar Spectrum with Fraunhofer Lines



Discrete spectral lines correspond to the energy levels of various **atoms** that are burning in the Sun.



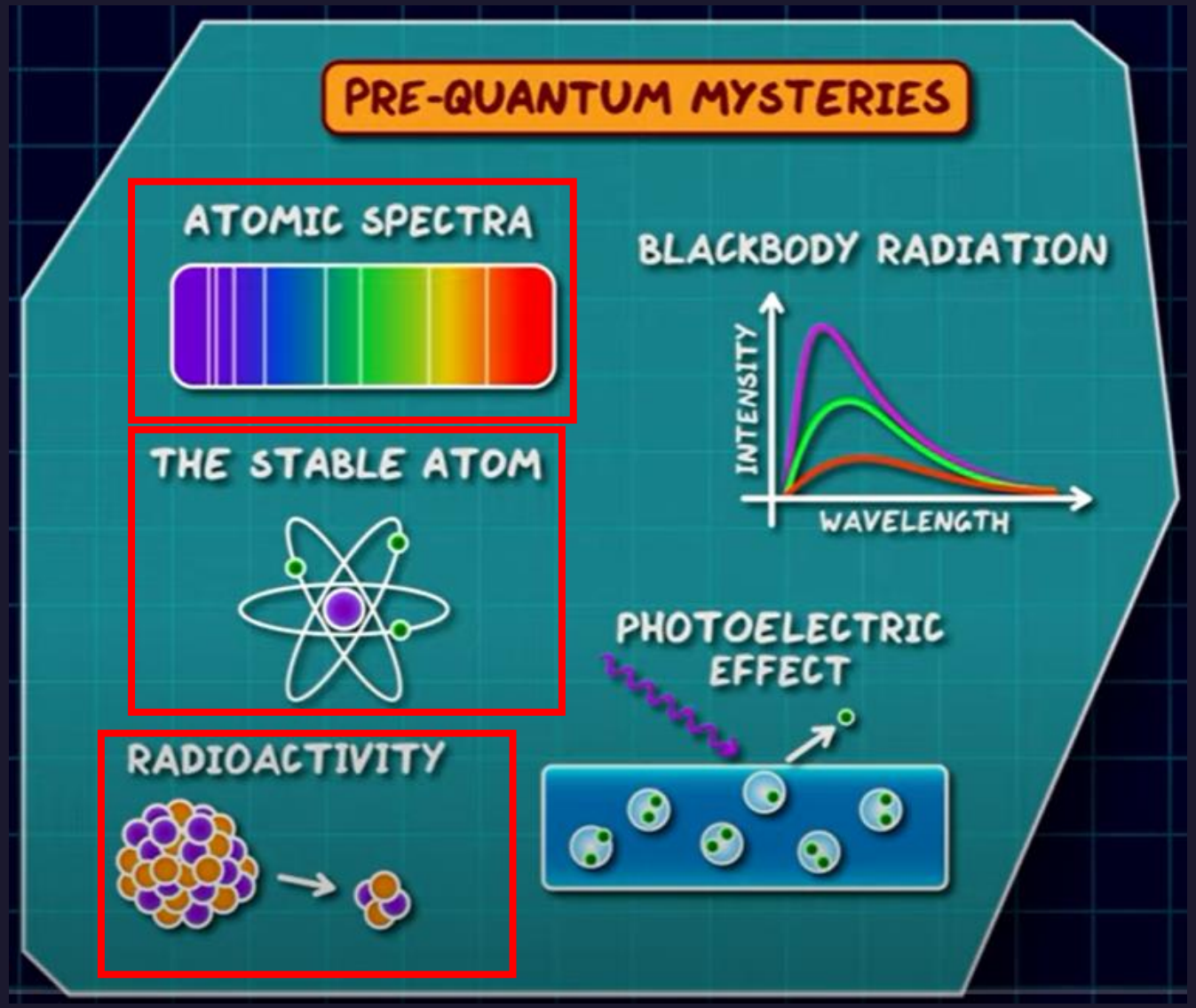
OPTICKS:
OR, A
TREATISE
OF THE
REFLEXIONS, REFRACTIONS,
INFLEXIONS and COLOURS
OF
LIGHT.
ALSO
Two TREATISES
OF THE
SPECIES and MAGNITUDE
OF
Curvilinear Figures.

LONDON,
Printed for SAM. SMITH, and BENJ. WALFORD,
Printers to the Royal Society, at the *Prince's Arms* in
St. *Paul's* Church-yard. MDCCIV.

The first, 1704, edition of *Opticks: or, a treatise of the reflexions, refractions, inflexions and colours of light.*

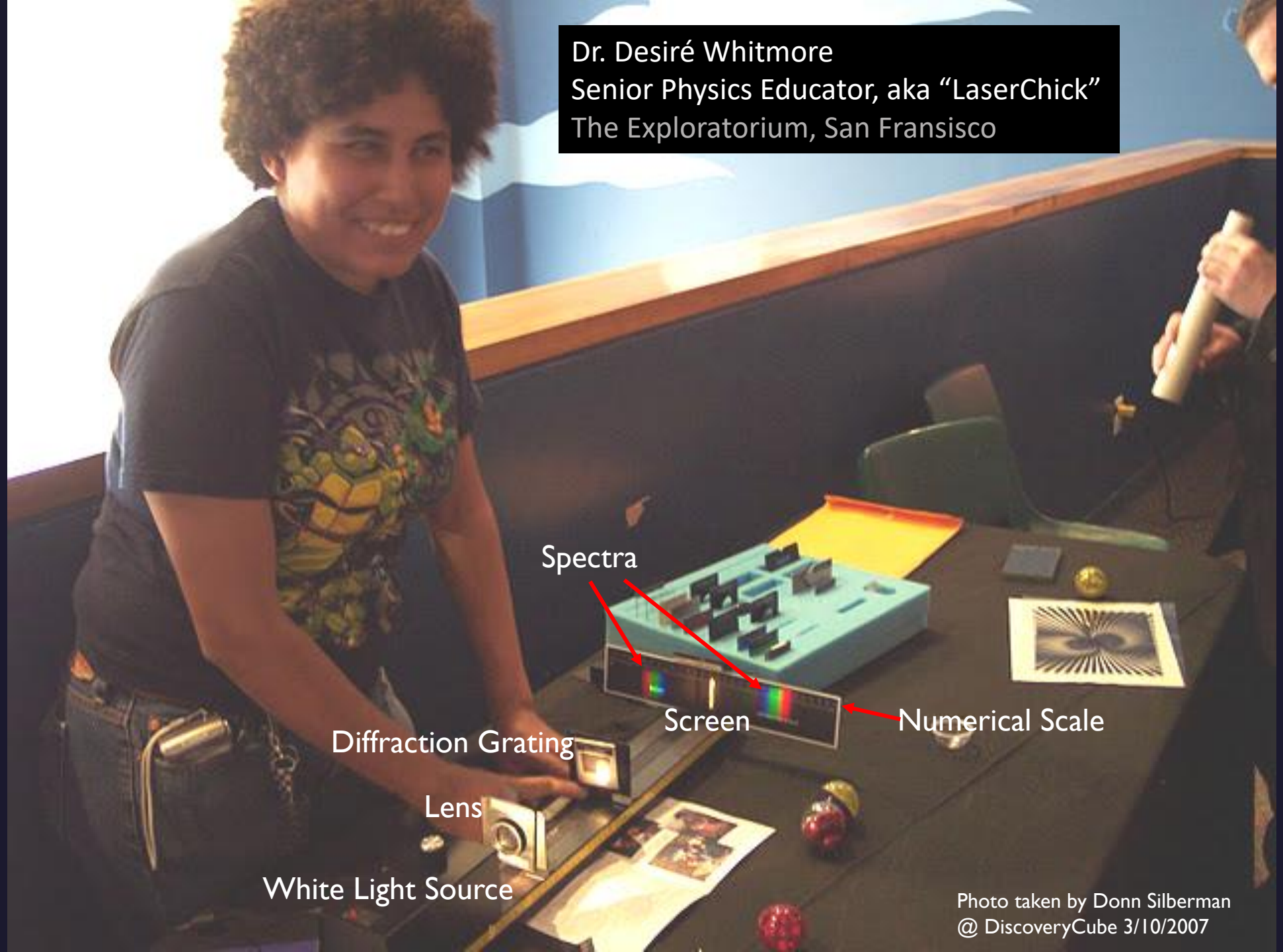
What about Atoms??

It gets a little complicated now !!!

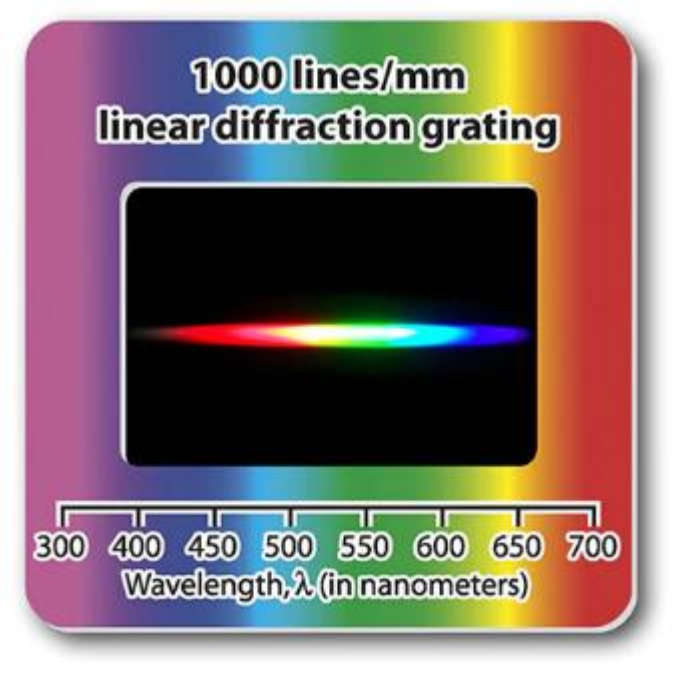


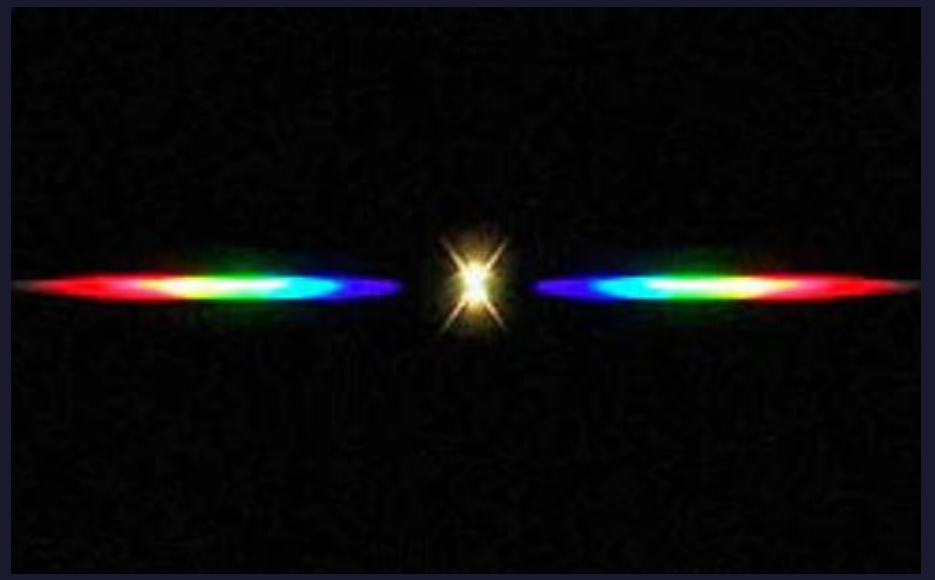
Map Videos - Domain of Science

The Map of Quantum Physics


Dr. Desiré Whitmore
Senior Physics Educator, aka “LaserChick”
The Exploratorium, San Fransisco
Spectra
Screen
Numerical Scale
Diffraction Grating
Lens
White Light Source
Photo taken by Donn Silberman
@ DiscoveryCube 3/10/2007

Diffraction Gratings





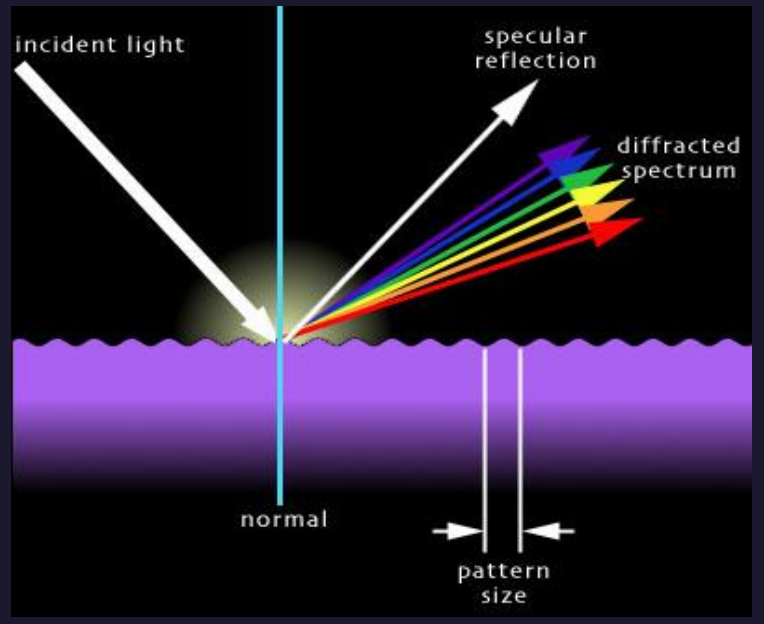
The grid of bumps in the plastic **diffract** the colors of the white light into the **visible spectrum**.

Diffraction Gratings

Colors are **mixed together** to make many types of lights.

Lights are separated into its constituent **colors** by **diffraction**

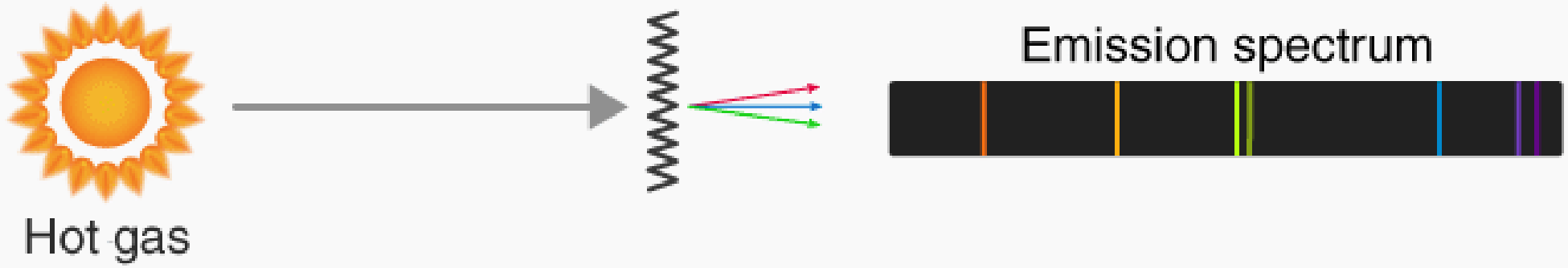
CDs or DVDs



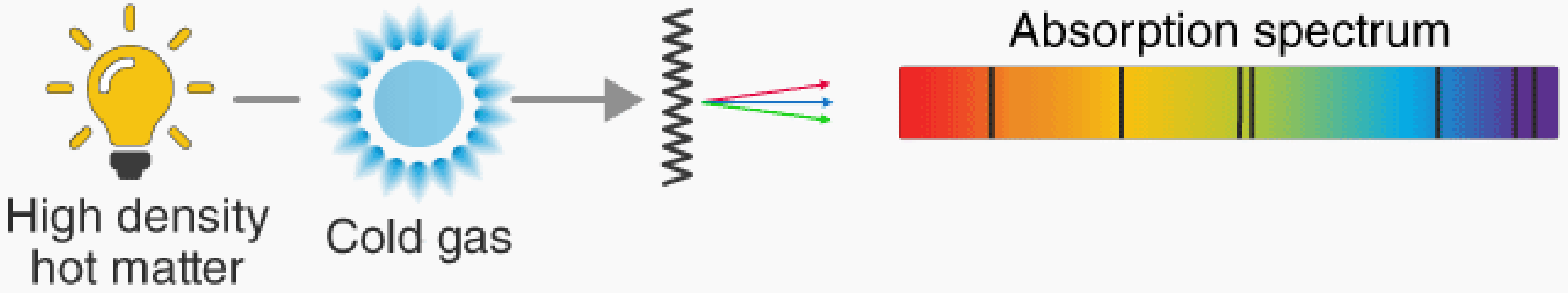
EMISSION VS. ABSORPTION SPECTRA

BYJU'S The Learning App

(a) Emission Spectra

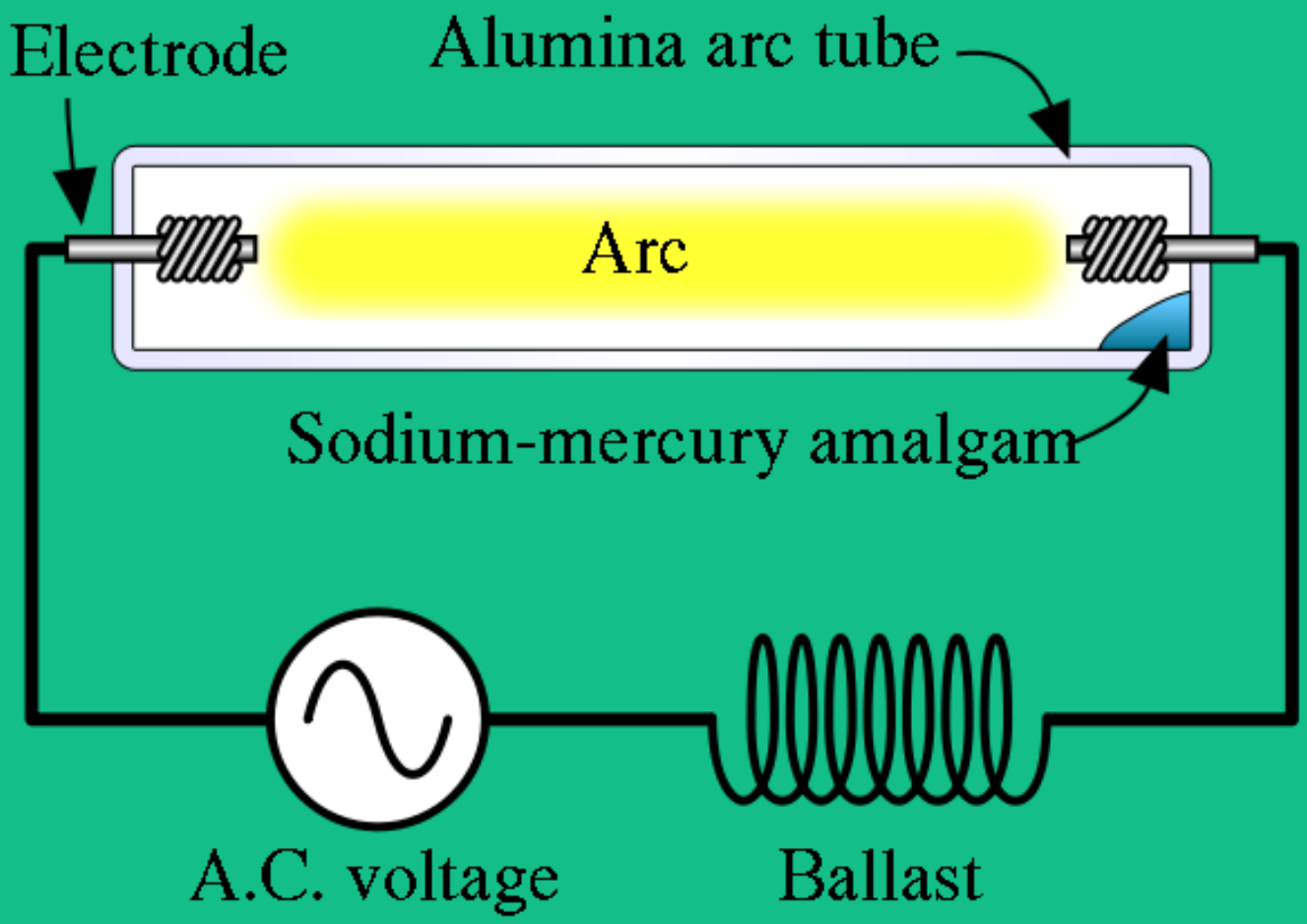


(b) Absorption Spectra



https://byjus.com/physics/difference-between-emission-and-absorption-spectra/

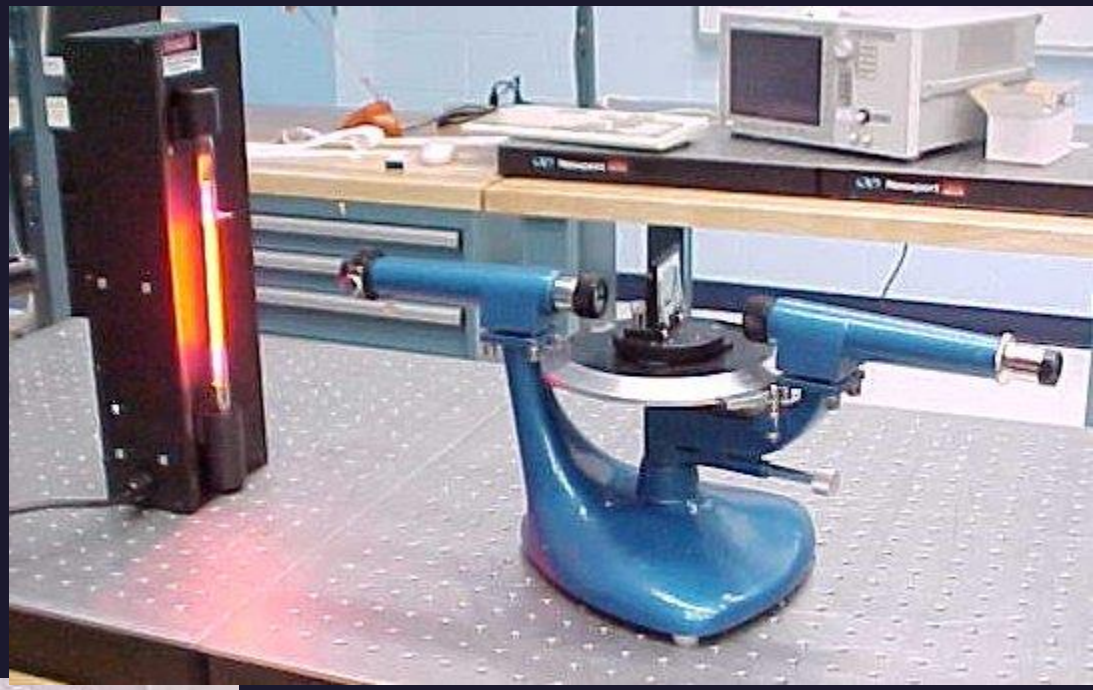
Gas-Discharge Lamps ("Neon" Lights)

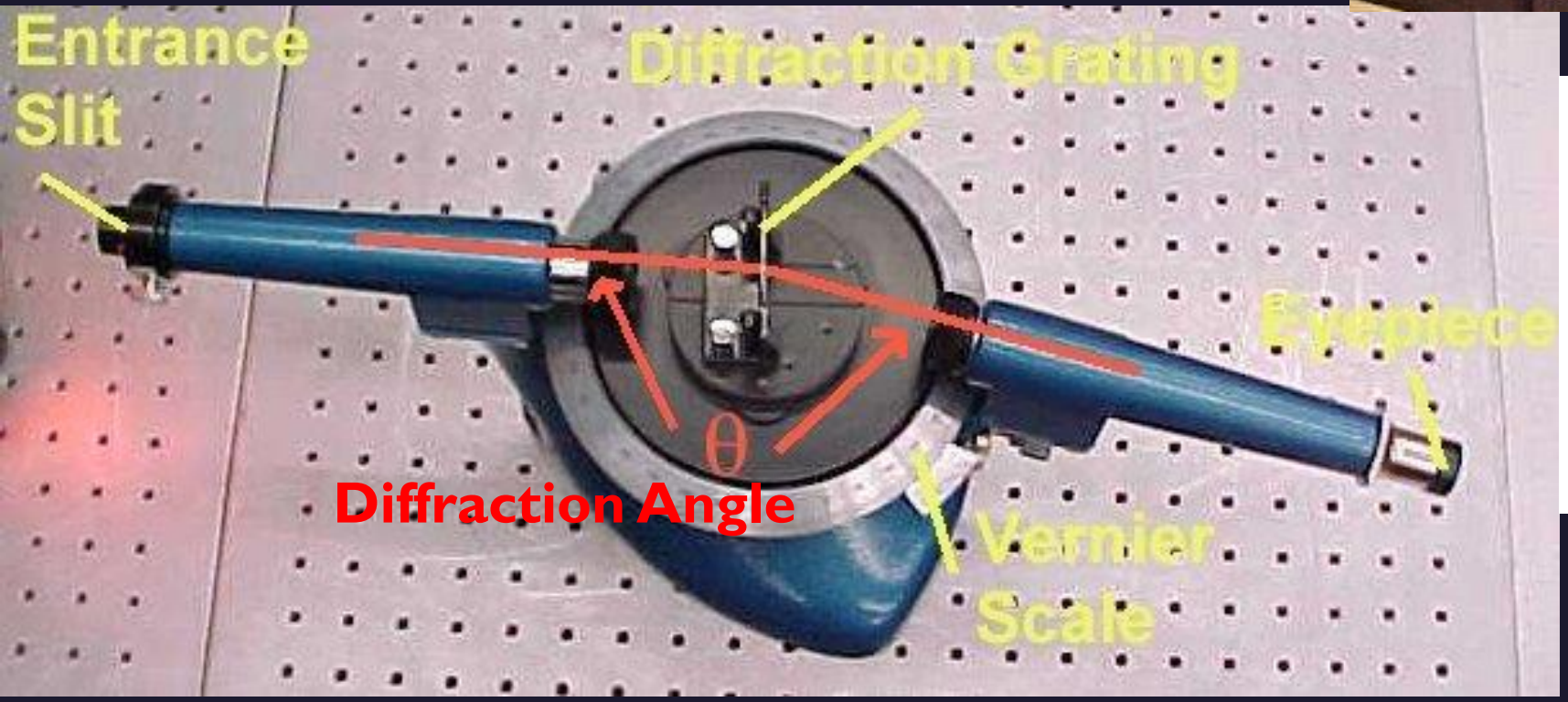


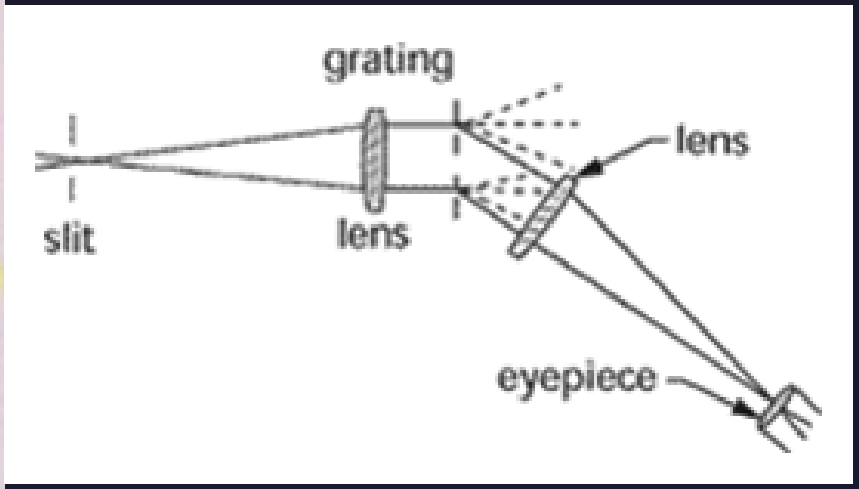
Spectrum Analysis

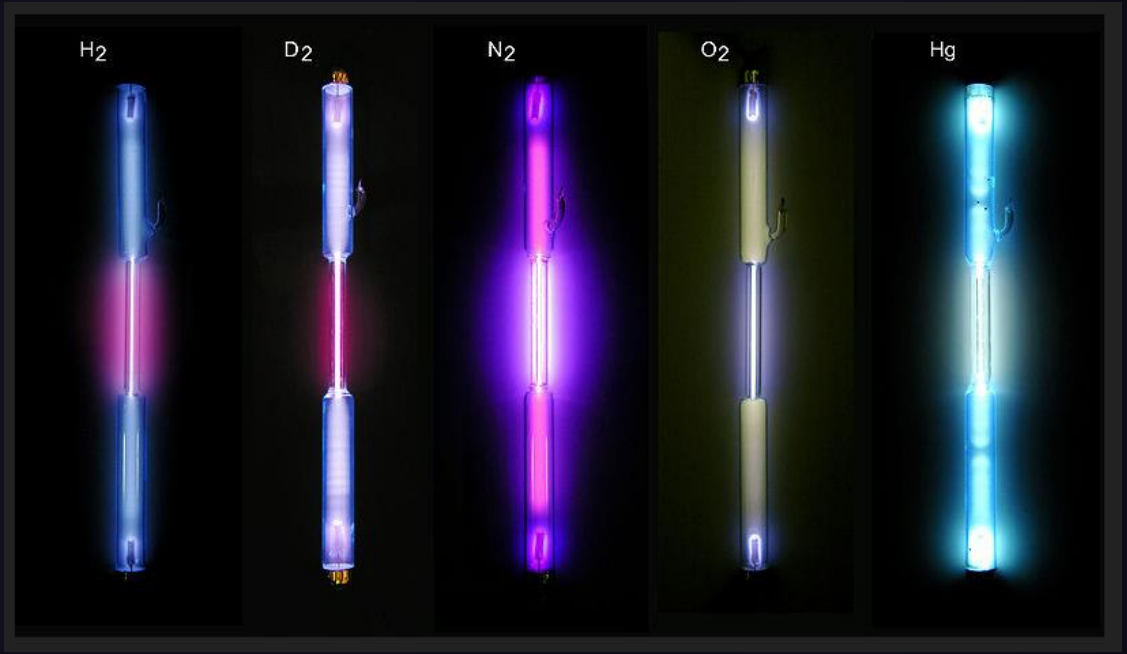
How a spectroscope works

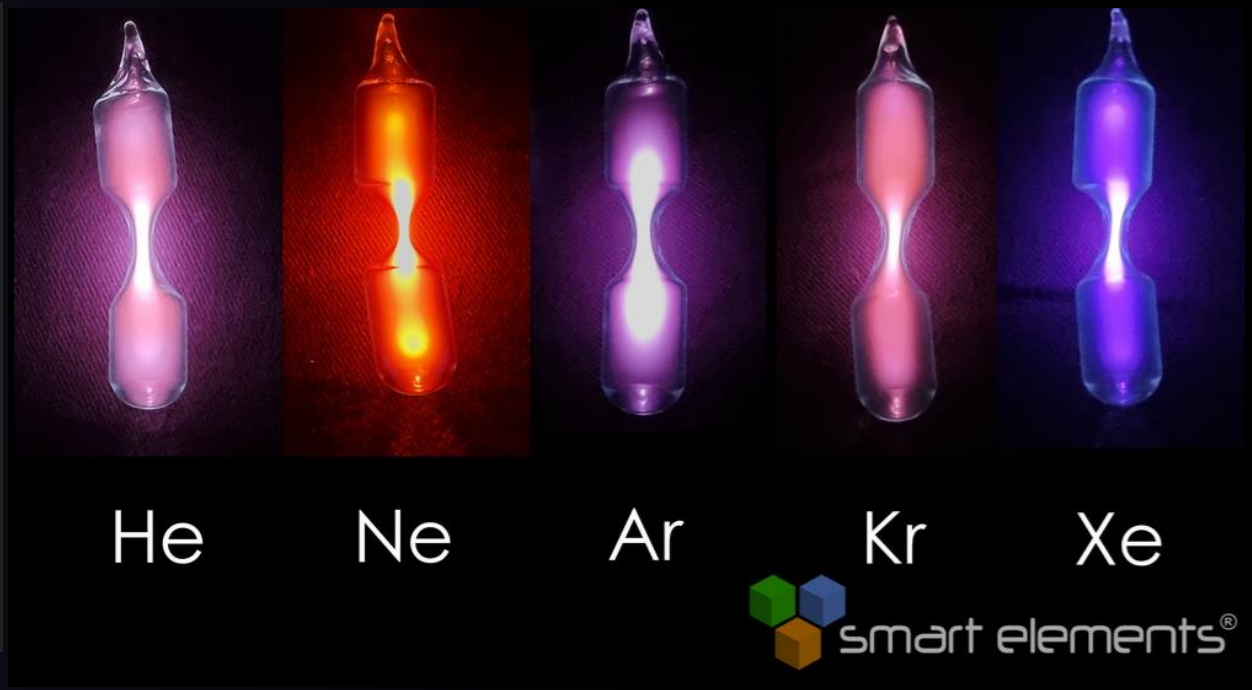
Like combining a telescope and a microscope



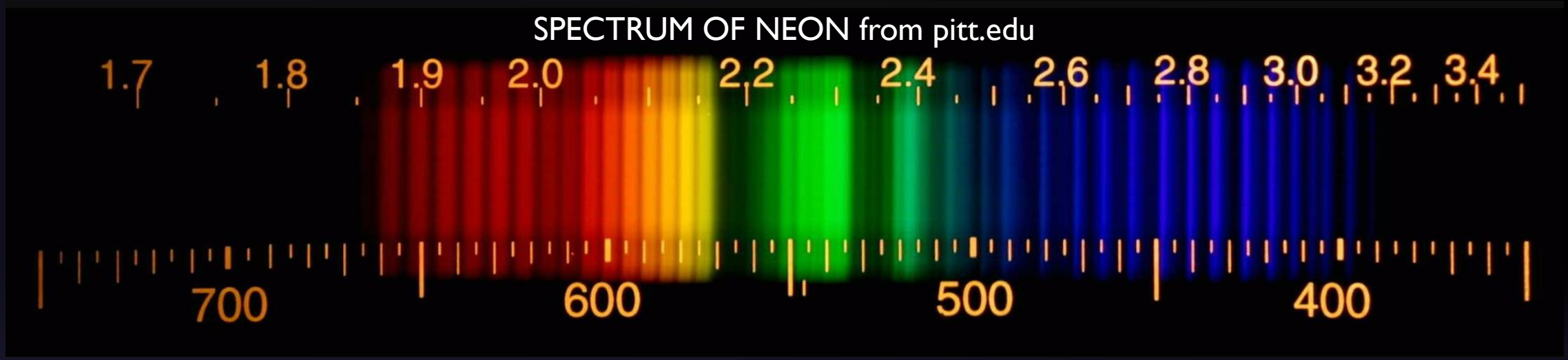








SPECTRUM OF NEON from pitt.edu



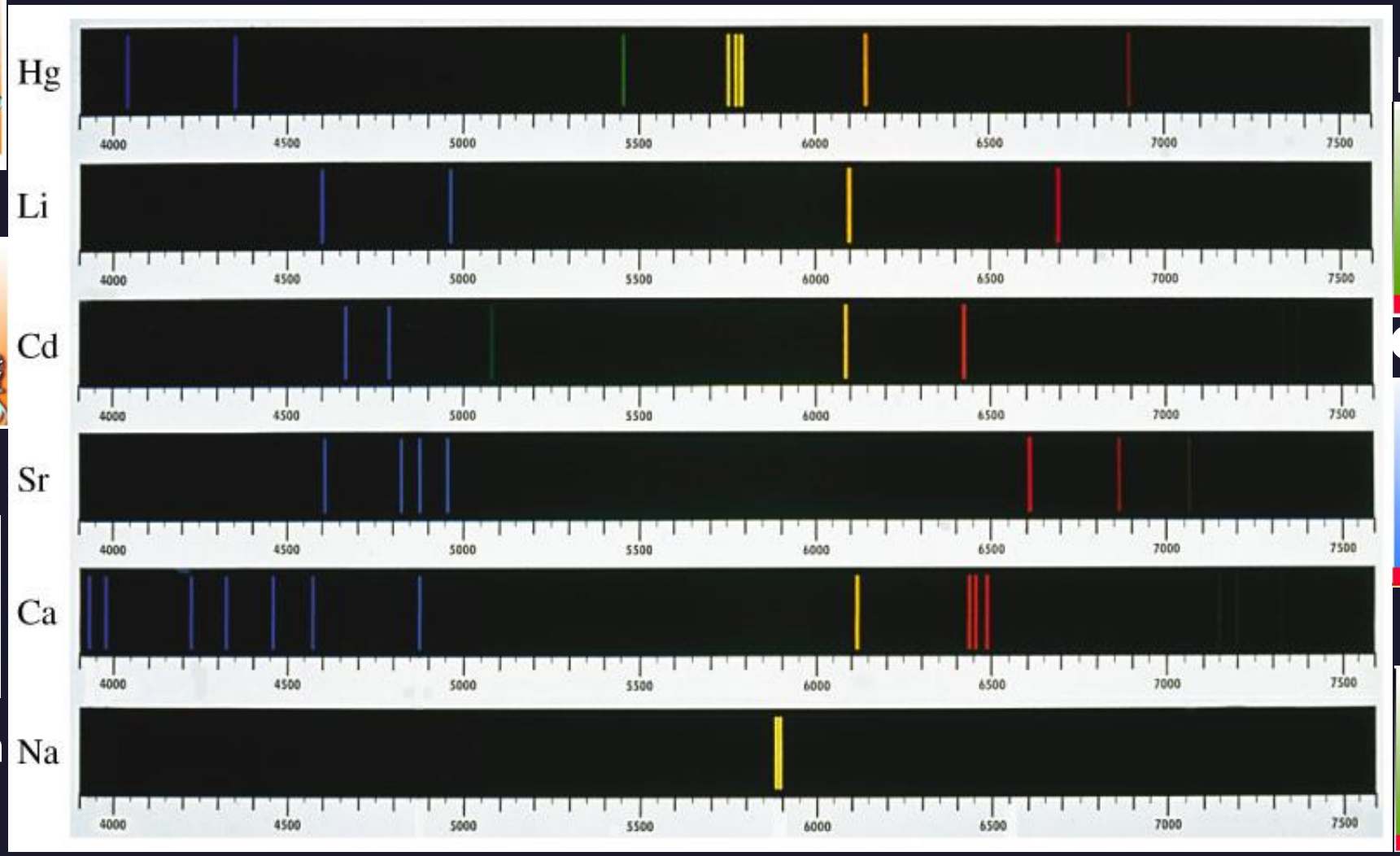
Diffraction

Atomic Emission Spectra

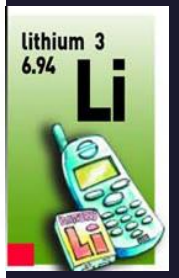
Lithium

Strontium

Sodium

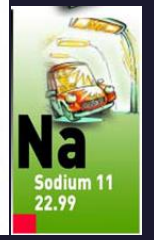


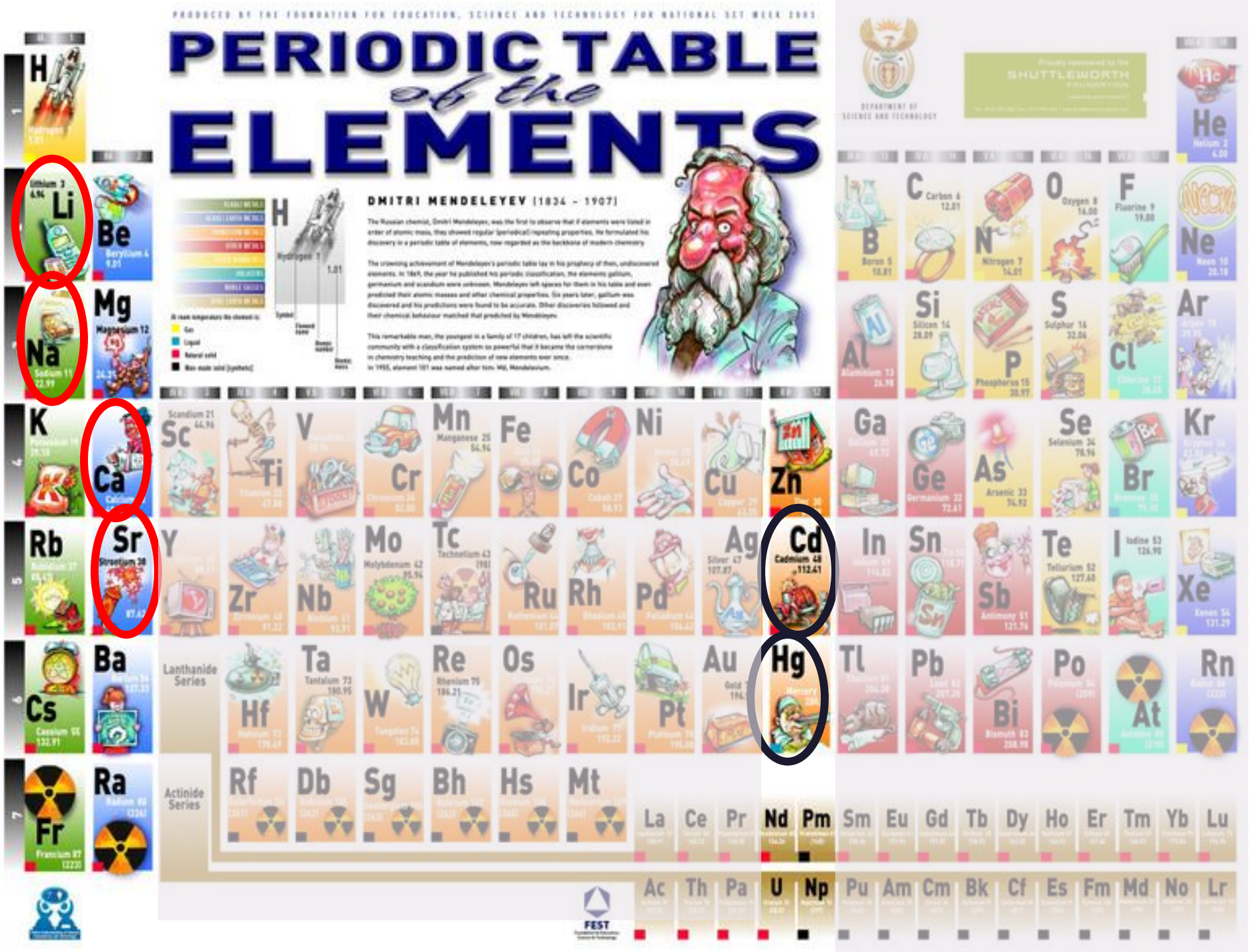
Mercury



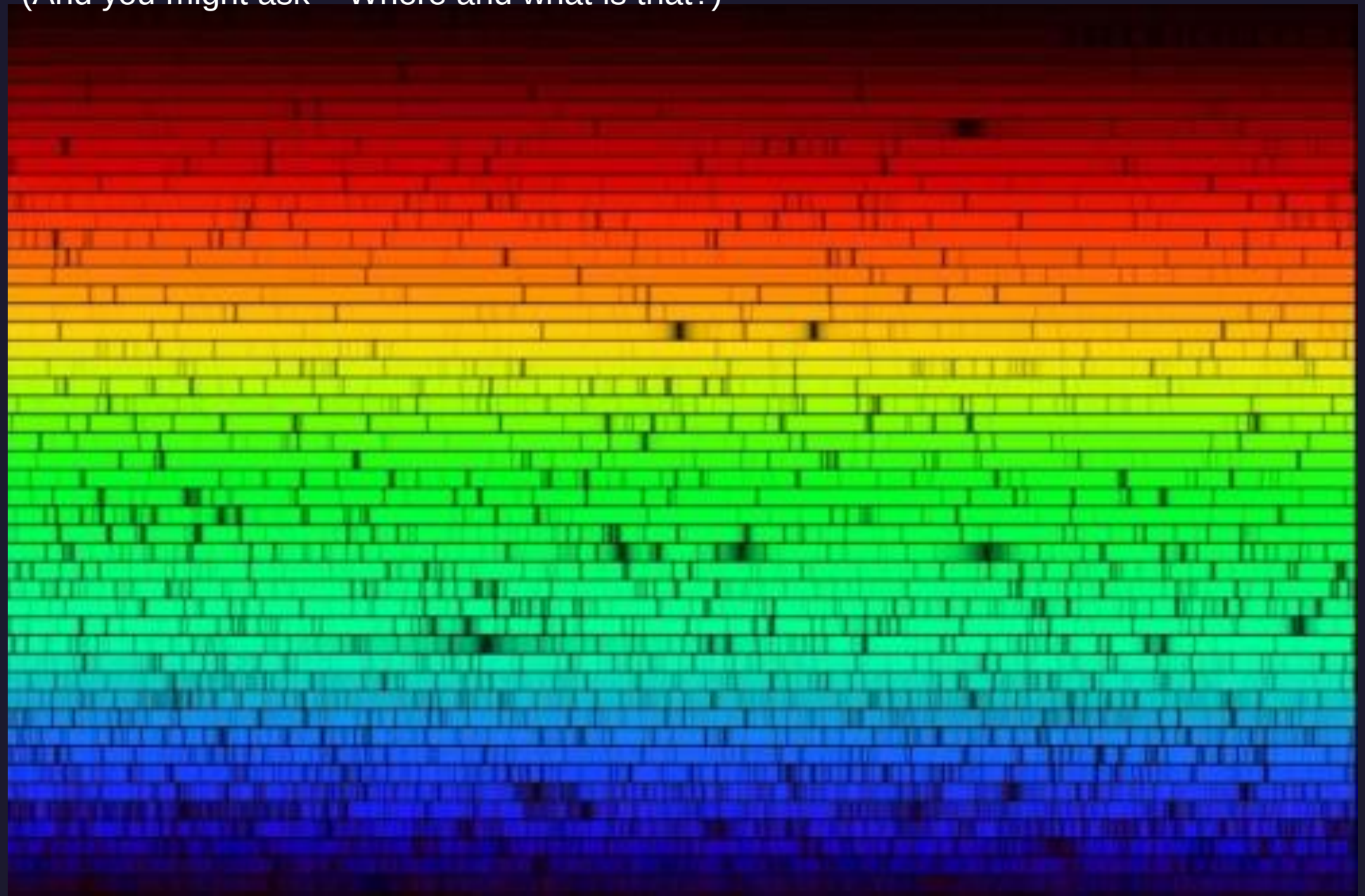
Cadmium

Calcium

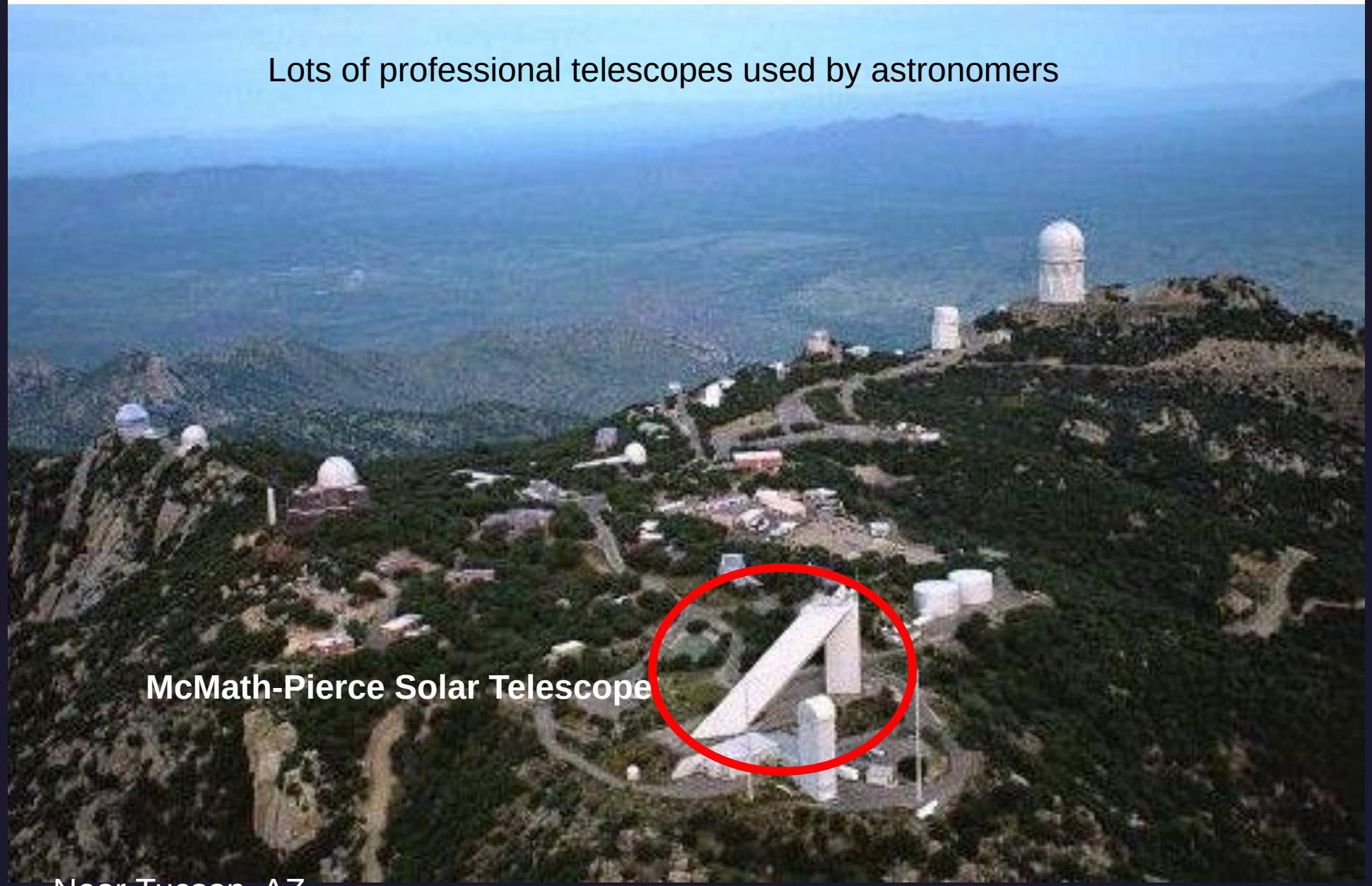



PERIODIC TABLE
of the
ELEMENTS
DMITRI MENDELEYEV (1834 - 1907)
Lanthanide Series
Actinide Series

Famous very high-resolution Solar Spectrum taken at Kitt Peak's Solar Observatory
Using the McMath-Pierce Solar Telescope.
(And you might ask – Where and what is that?)

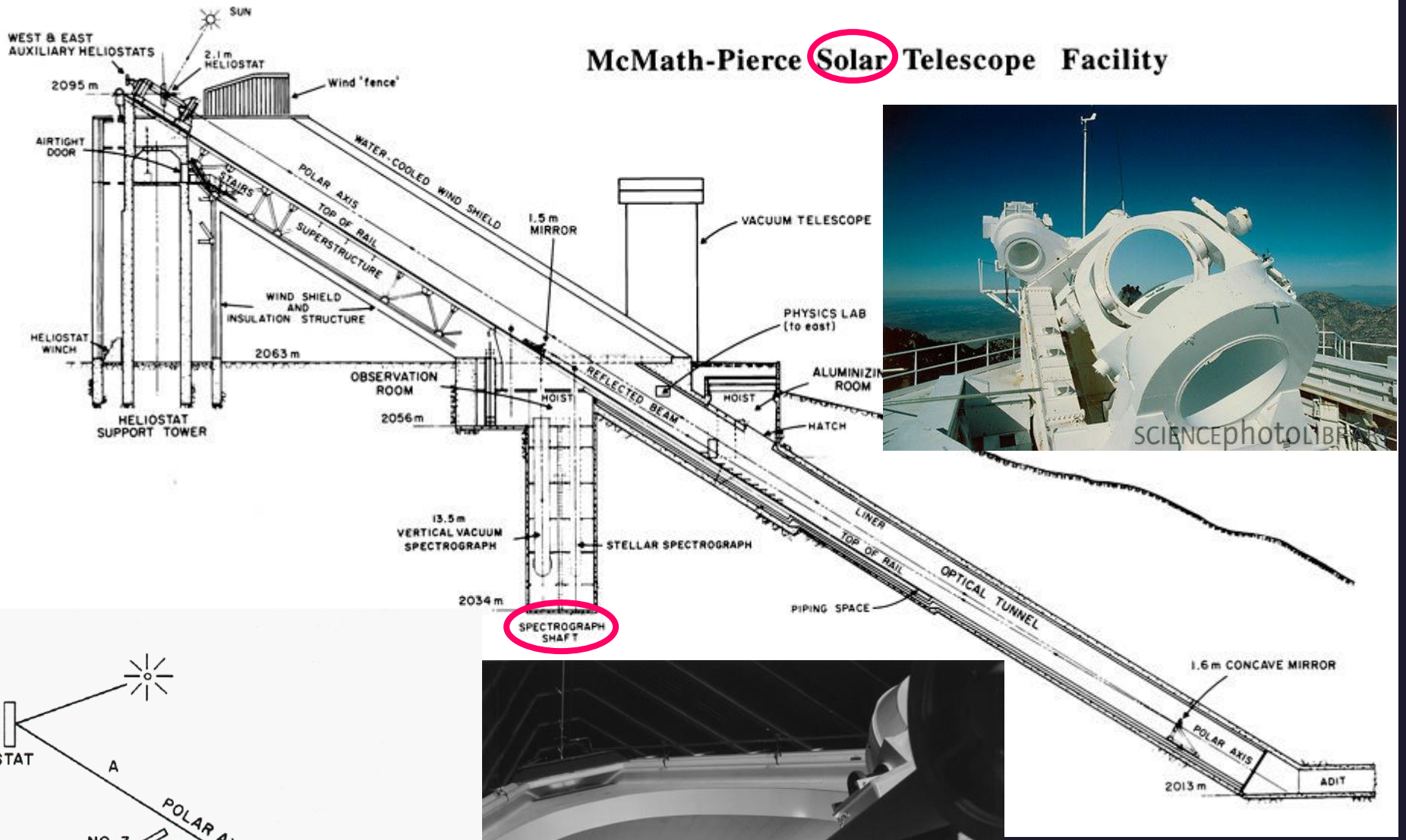


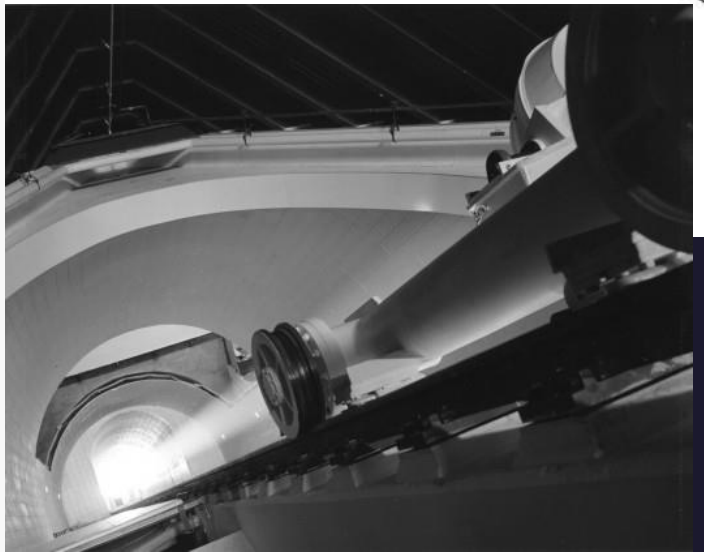
KITT PEAK NATIONAL OBSERVATORY



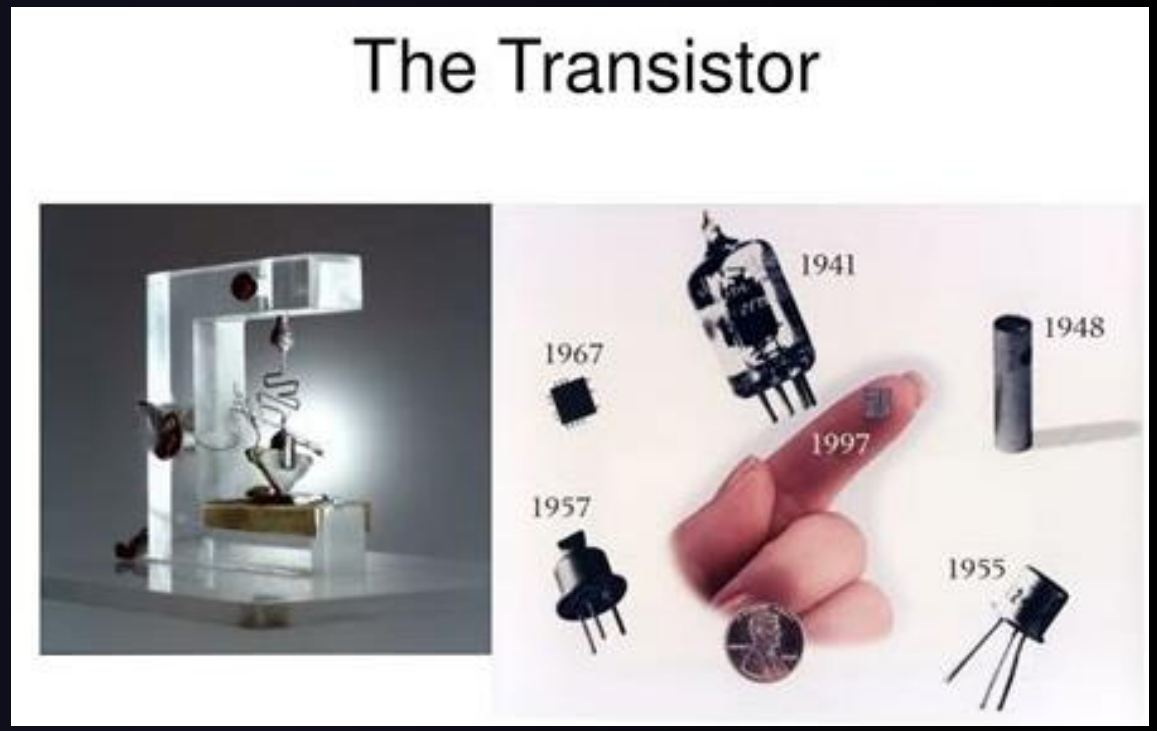
Near Tucson, AZ

McMath-Pierce Solar Telescope Facility



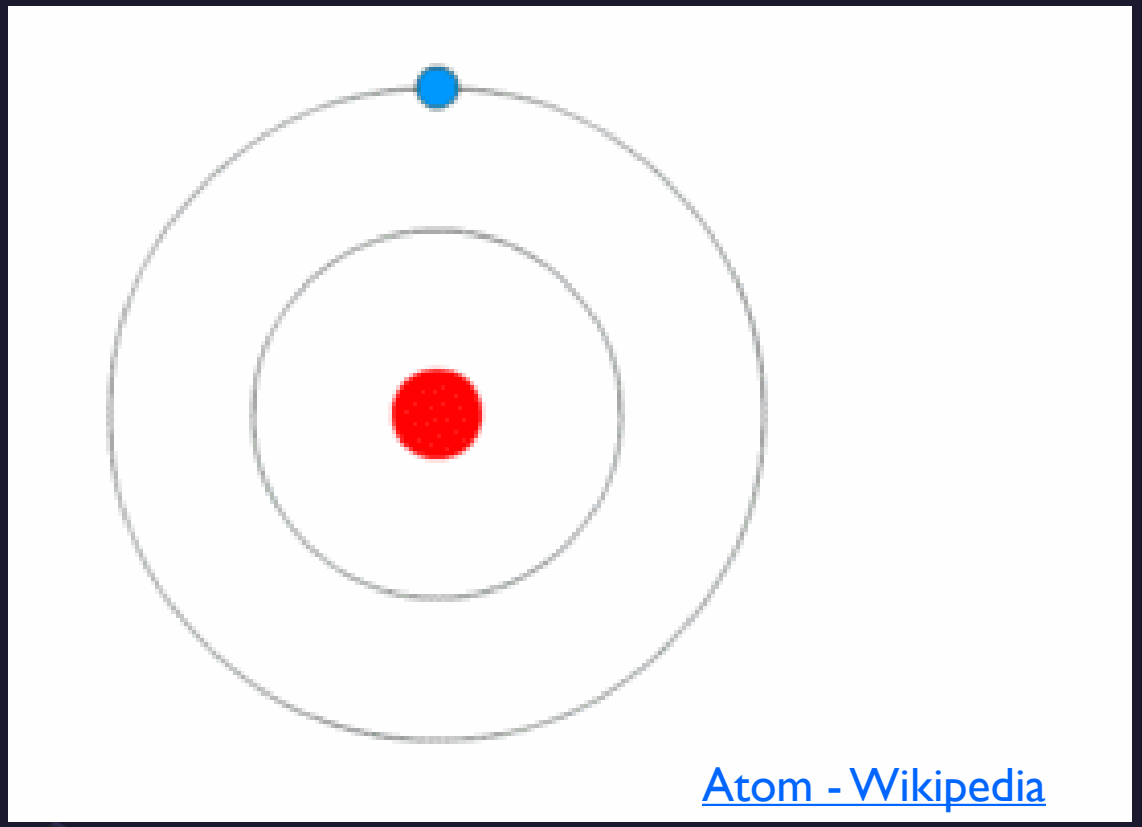


History of the transistor – Wikipedia "After WWII, Shockley decided to attempt the building of a triode-like semiconductor device. He secured funding and lab space, and went to work on the problem with Bardeen and Brattain. John Bardeen eventually developed a new branch of quantum mechanics known as surface physics to account for the "odd" behavior they saw, and Bardeen and Walter Brattain eventually succeeded in building a working device."



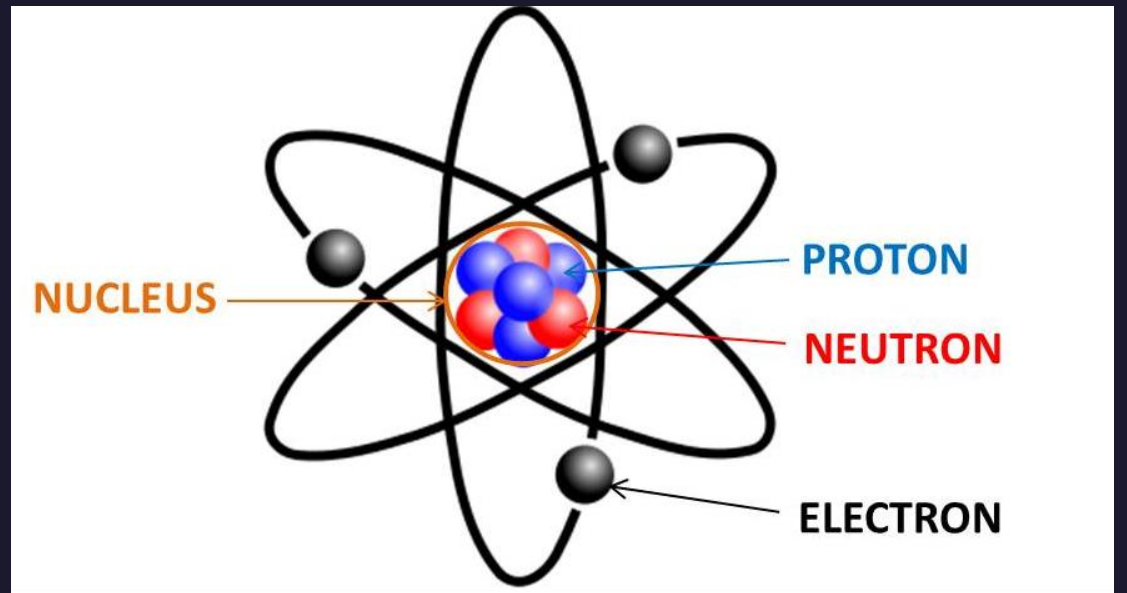
What are atoms & How do we know?

The Bohr model of the atom



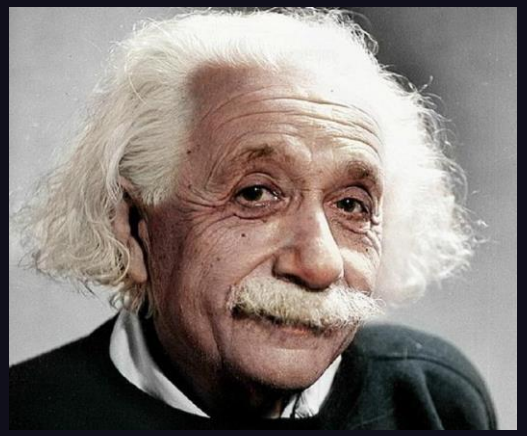
Atom - Wikipedia

The Bohr model of the atom, with an electron making instantaneous "quantum leaps" from one orbit to another with gain or loss of energy. This model of electrons in orbits is obsolete.



Atoms – EWT (energywavetheory.com)

Fifth Solvay International Conference on **Electrons and Photons** October 1927



Albert Einstein

Niels Bohr

Erwin Schrödinger

The Solvay Conference, founded by the Belgian industrialist Ernest Solvay in 1912, was considered a turning point in the world of physics. Located in Brussels, the conferences were devoted to outstanding preeminent open problems in both physics and chemistry.

The most famous conference was the October 1927 Fifth Solvay International Conference on **Electrons and Photons**, where the world's most notable physicists met to discuss the newly formulated quantum theory. The leading figures were Albert Einstein and Niels Bohr.

Einstein, disenchanted with Heisenberg's uncertainty principle, remarked "God does not play dice". Bohr replied: "Einstein, stop telling God what to do". 17 of the 29 attendees were or became Nobel Prize winners, including Marie Curie, who alone among them, had won Nobel Prizes in two separate scientific disciplines.

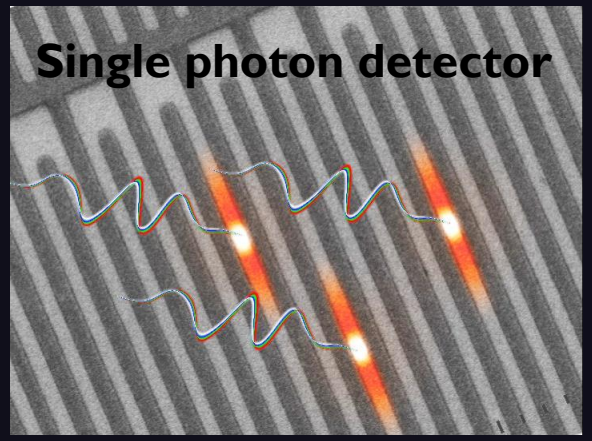
From Wikipedia: QUANTUM

In physics, a quantum is the minimum amount of any physical entity involved in an interaction. The fundamental notion that a physical property can be "quantized" is referred to as "the hypothesis of quantization".

[1] This means that the magnitude of the physical property can take on only ***discrete values*** *consisting of integer multiples of one quantum.*

Can't have 1 ½ photons
Or ¾ of an electron

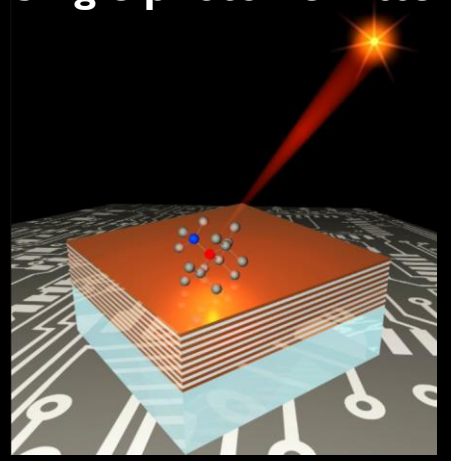
Graphic representation of an **electron (red O)** moving from one energy level to another, emitting or absorbing a **photon (Energy)** of light.



1-singlephoton.jpg (716×536) (b-cdn.net))

Samsung Display - Quantum Dot Physics

Single photon emitter

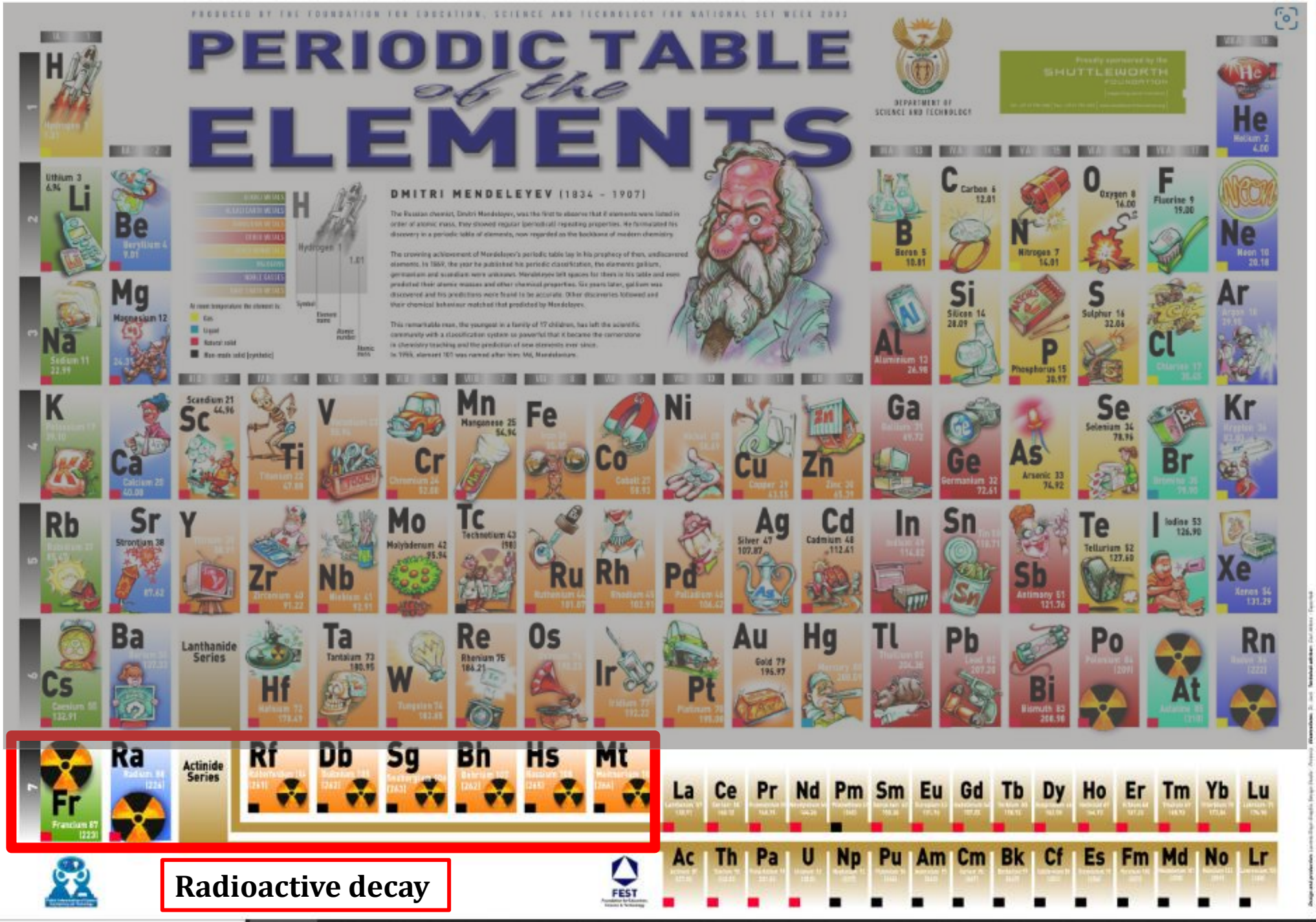


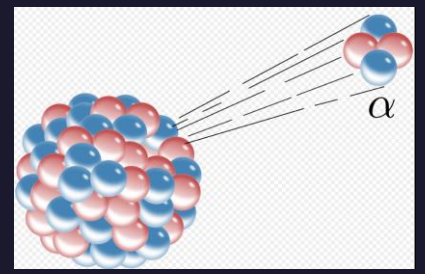
singlephoton.jpg (1000×1413) (b-cdn.net)

$E = h\nu$ — frequency of radiation, sometimes written as f giving expression E = hf. Quantum energy of a photon.

h = Planck's constant = 6.626×10^{-34} Joule·sec = 4.136×10^{-15} eV· s

$E=mc^2$





Alpha decay by a nucleus emits an alpha particle made of helium's nucleus

Quantum Weirdness

(cat in a closed box – you can't see inside)

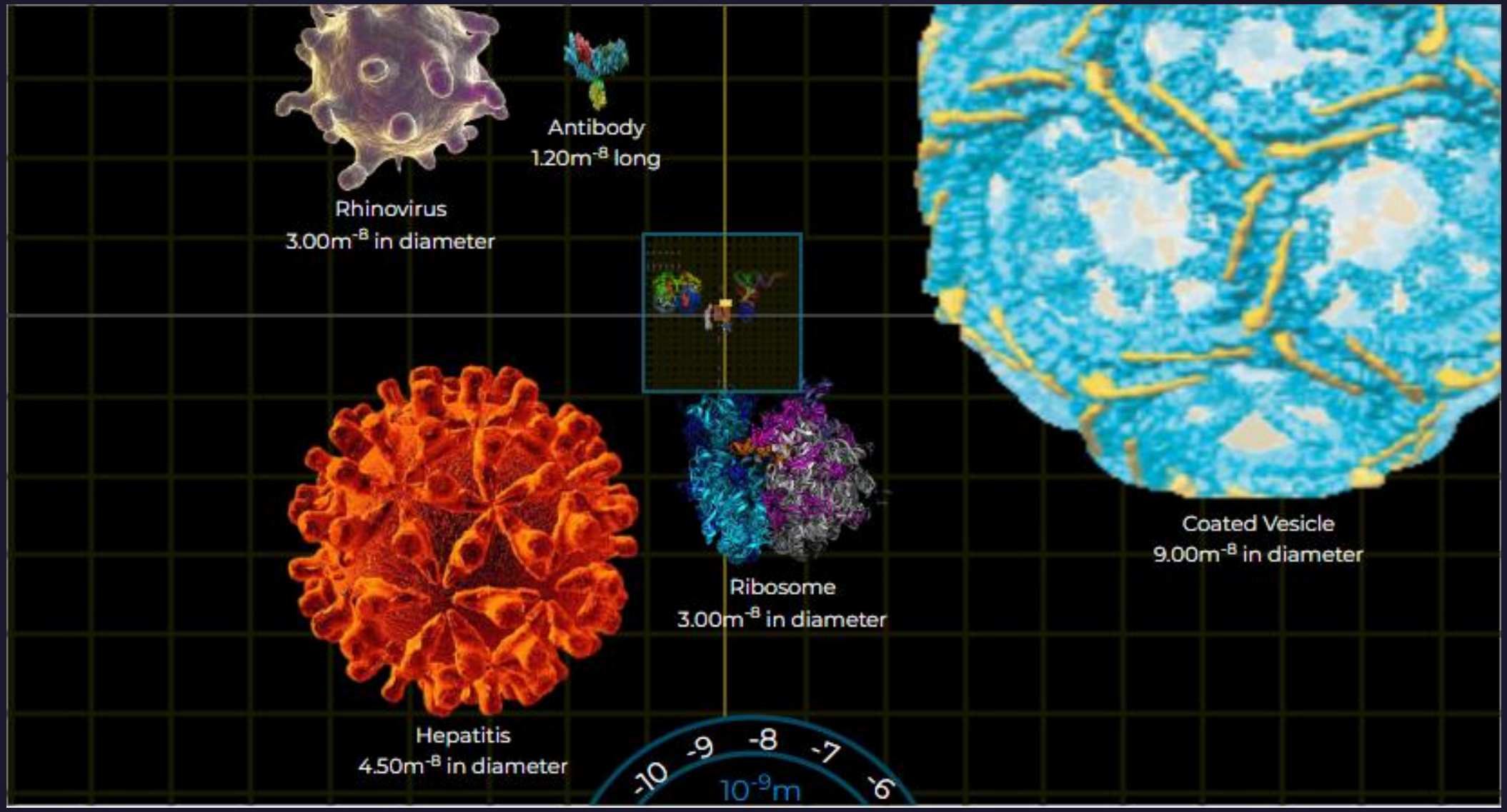
Radioactive Trigger

Drops the hammer at an unknowable time.

Breaks the bottle Containing poison.

Schrödingers-cat.jpg (1280×720) (debuglies.com)

Schrödinger's Kittens



Where in the scale of things does Quantum effects take over?

[Magnifying The Universe: Interactive Journey from the Smallest Particles to the Largest Galaxies | Academic Influence]

Experience Life in the QuantumOptics Age

OpticsAge is a focal point for Donn Silberman's past Optics Education Adventures
Donn has retired from most of his educational outreach activities and his fulltime job at Starrett.
This website will be periodically maintained as an educational resource.

Donn is now focused on his Quantum Explorations and is consulting on EdQuantum.

Follow the Digital White Rabbit

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Things at the Atomic Scale are very different than at the human scale.

Summary

- The Quantum World underlies our modern civilization.
- And Quantum is about take humanity to the next level.
- **You can help make it happen.**

Thank You

Donn Silberman

Optics Institute of Southern California

http://oisc.net