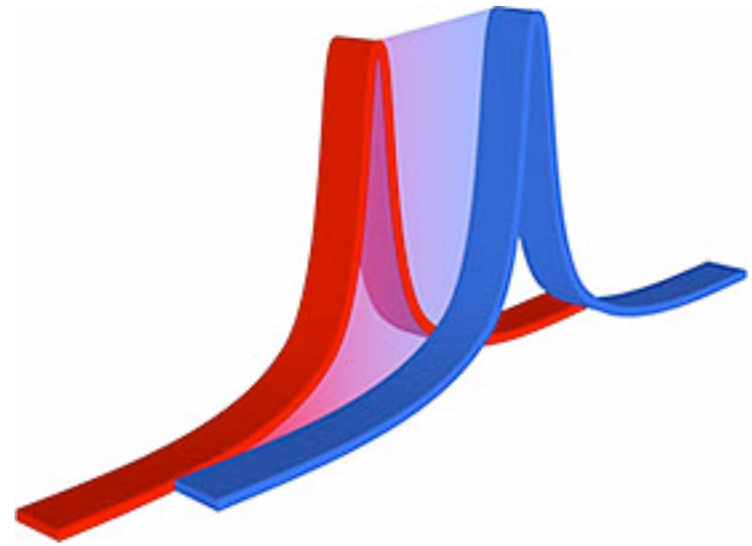
PHY385-H1F Introductory Optics

Class 5 – Outline: Sec. 3.5, 3.6, 3.7

- Emission
- Selective Absorption
- Dispersion
- The dispersion equation
- The Electromagnetic Spectrum

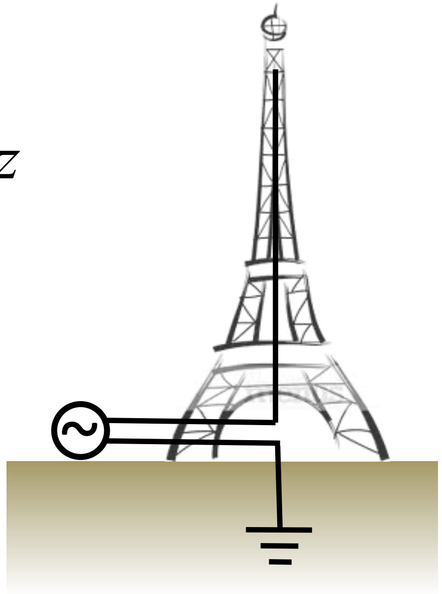


In-Class Task from Last time.. I asked:

Consider a big transmitting tower, which is aligned with the vertical $+z$ axis. Choose coordinates so that $+z$ is up, $+x$ is East, and $+y$ is North.

An AC generator is connected to the tower, sending a current up and down its length.

If you are in a car 1 km East of the tower:



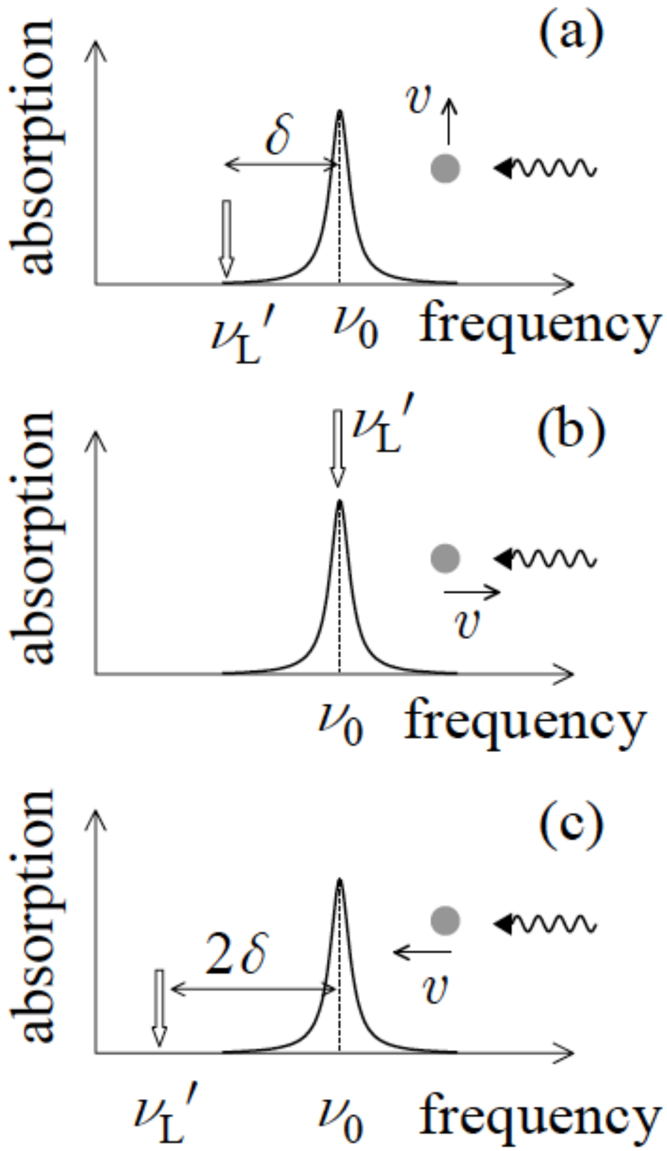
1. Along which direction (x, y or z) will the electric field oscillate near your car? ***z***

The antenna is like an oscillating electric dipole in the ±z direction. The dipole field in a plane perpendicular to the dipole which passes through the centre of the dipole is parallel to the dipole

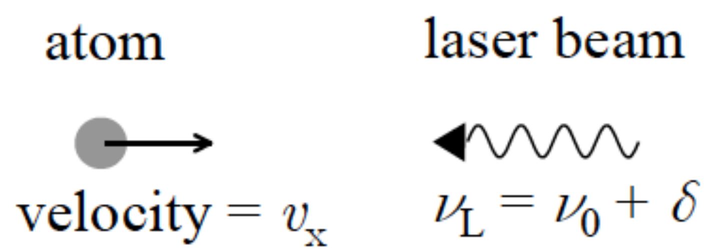
2. Along which direction (x, y or z) will the magnetic field oscillate near your car? ***y***

The current oscillates in the ±z direction, and by the RHR the B-field will be in horizontal circles. If you are East of the antenna, this makes the B-oscillations North-South, along y

Doppler cooling mechanism



- absorption only for case (b)
- laser must be tuned below the transition
- frequency must be tuned as atoms cool

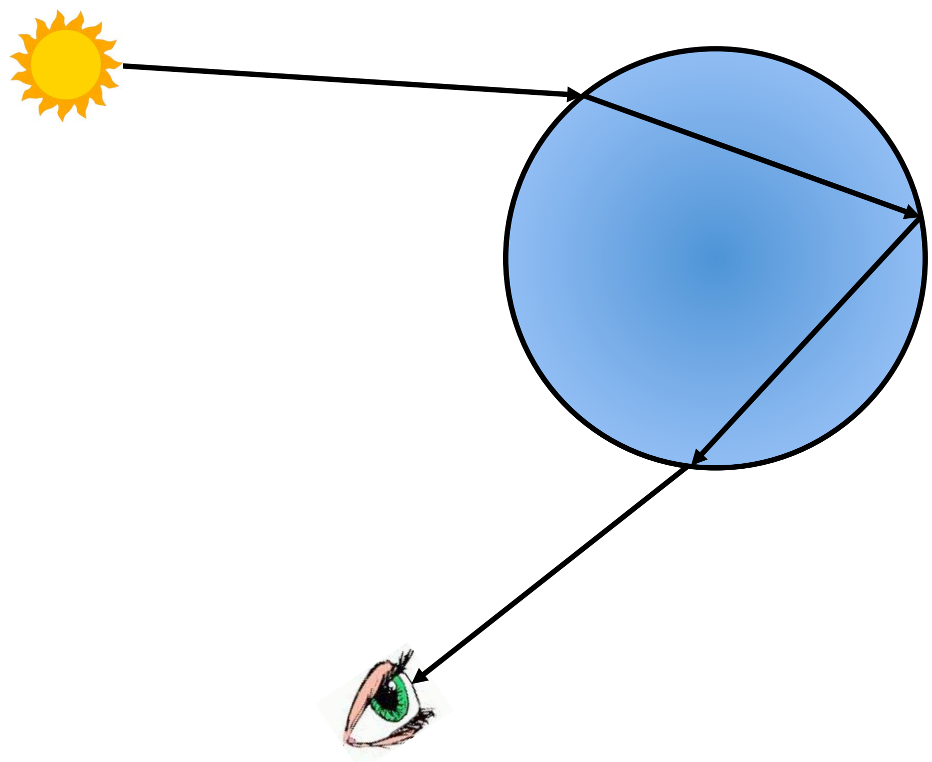


$$\delta = -\frac{v_x}{c}\nu_0$$

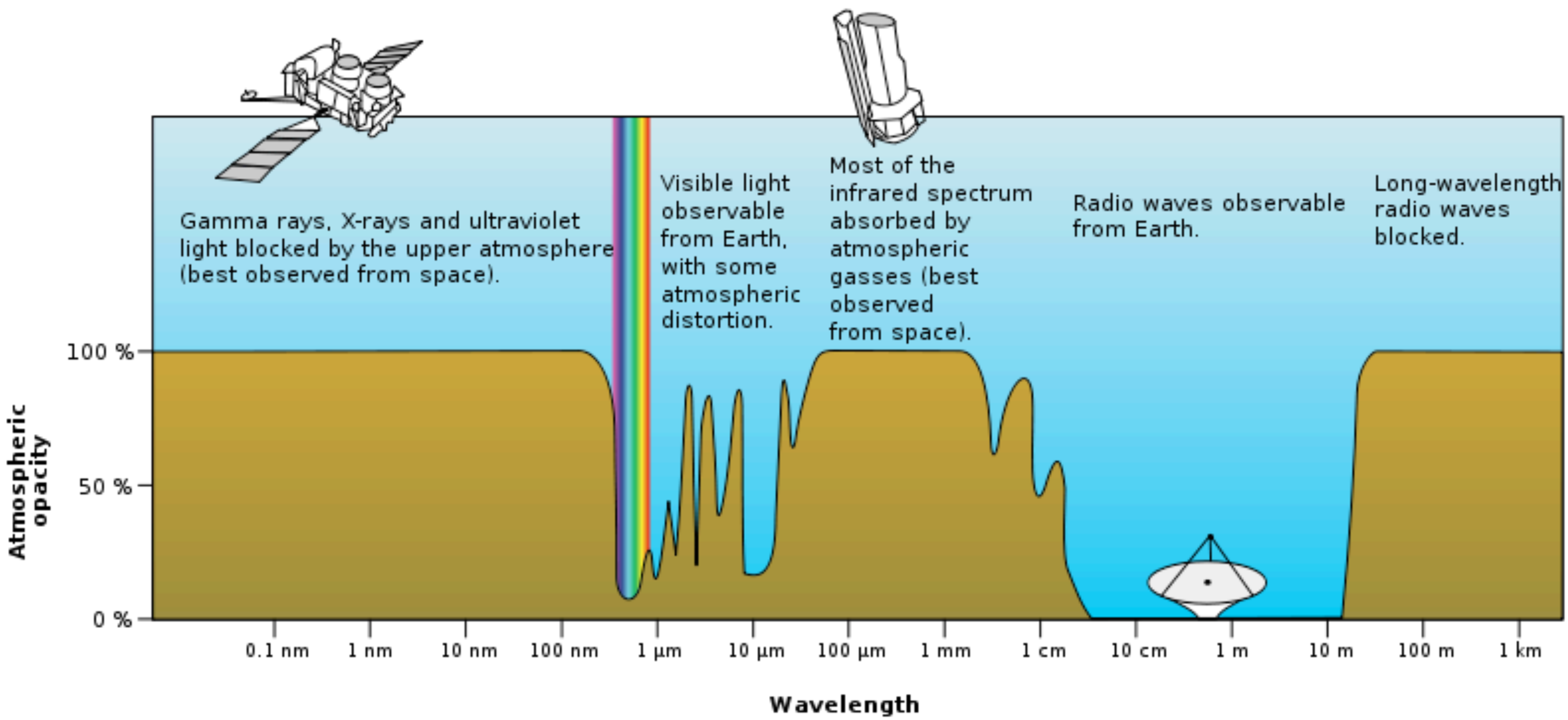
5-minute In-Class Task

- Please take out a piece of paper that you don't mind handing to me at the end
- WRITE YOUR NAME at the top of the piece of paper
- Discussion with your friends or me during this task is ***encouraged!***

You see a big rainbow, arcing over the Northern horizon. The sun is behind you, to the South. Is red on TOP or on the BOTTOM of the rainbow arc?

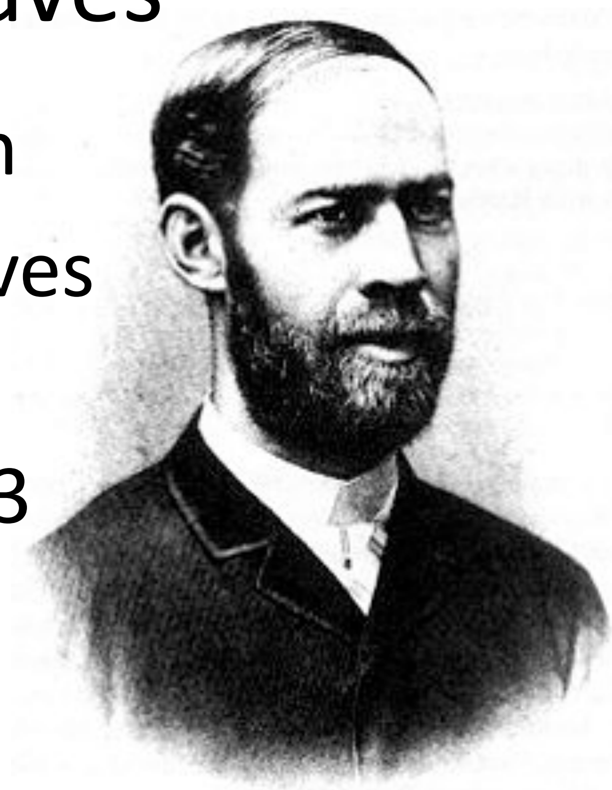


Opacity of Earth's Atmosphere



Radiofrequency Waves

- 0 to 1 GHz, wavelengths > 30 cm
- In 1887, Hertz created radio waves with sparks
- Radio Astronomy started in 1933 when Karl Jansky accidentally discovered Sagittarius A – the black hole at the centre of the Milky Way Galaxy



Heinrich Hertz

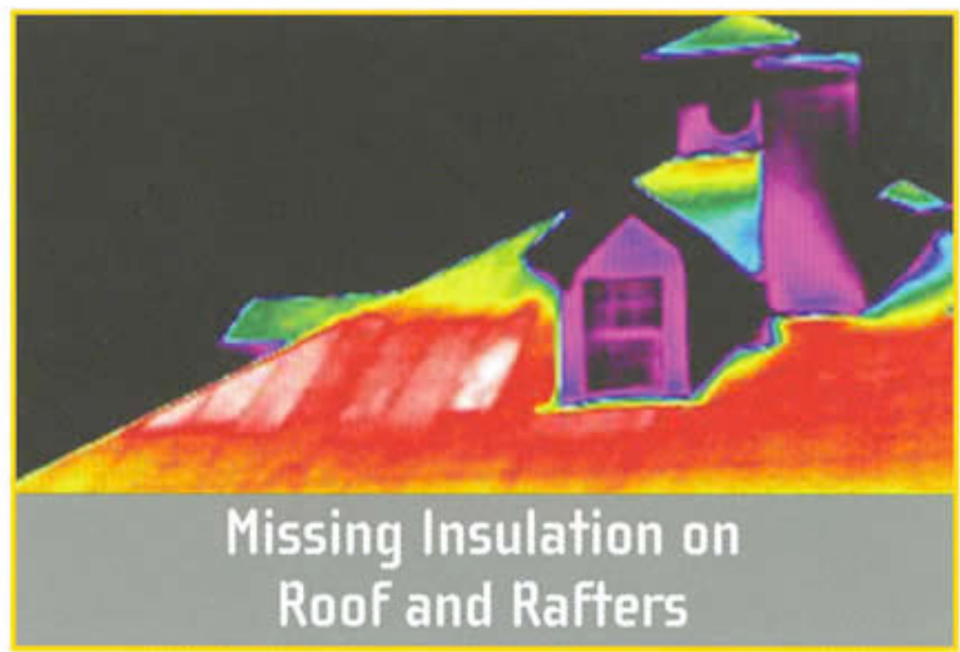
- Radio waves travel at the speed of light, and are used to transmit audio signals, video signals and digital information.

Microwaves

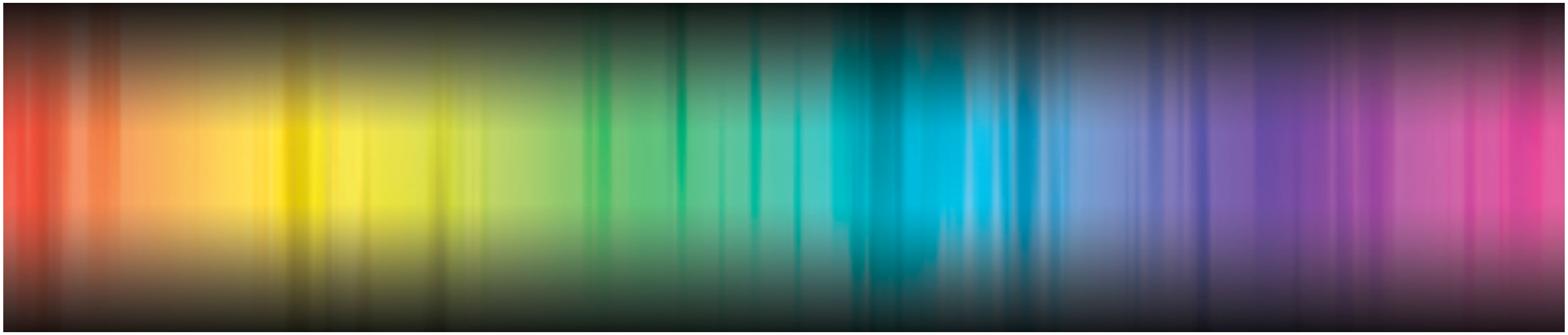
- 1 to 300 GHz, or 1 mm to 30 cm
- Polarized molecules can be excited via rotational modes, and so absorb heat when exposed to microwaves.
- Microwave ovens use 2.45 GHz, which is a good rotational resonance of the water molecule.
- Microwaves are used in communication: cell phones, radio astronomy, communications with satellites.
- No, your cell phone cannot pop popcorn.

Infrared

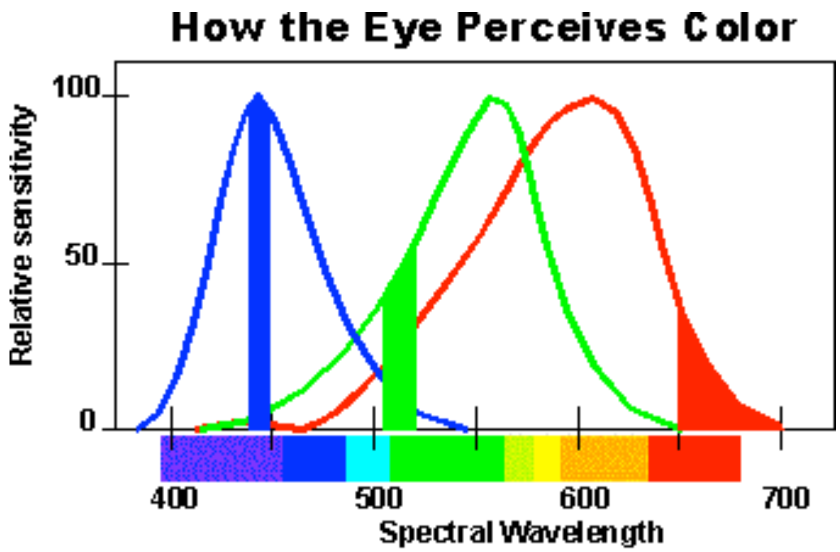
- 780 nm up to 1 mm.
- "Heat waves" – most molecules have lots of vibrational and rotational resonances in the IR
- Room temperature objects emit blackbody radiation which peaks in the infrared.
- Digital cameras detect wavelengths up to 1000 nm: near IR

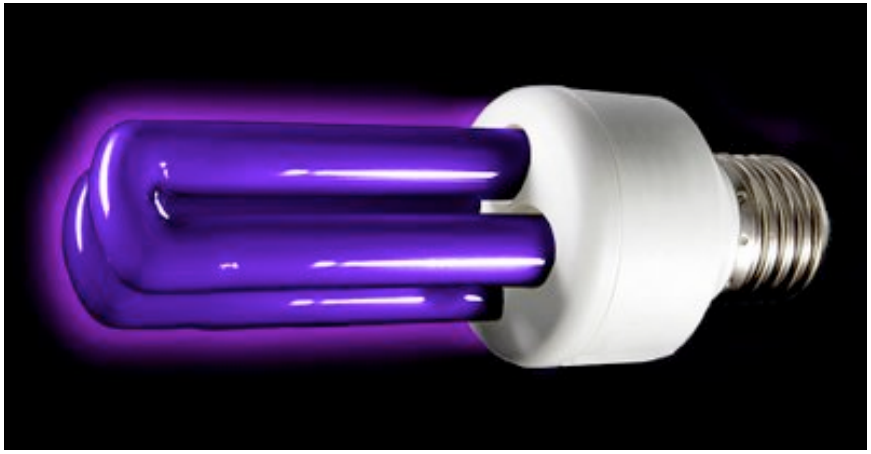


Light



- Hecht says: 455 to 780 nm. Personally, I can't see light beyond about 700 nm. And I am able to see violet down to about 420 nm.



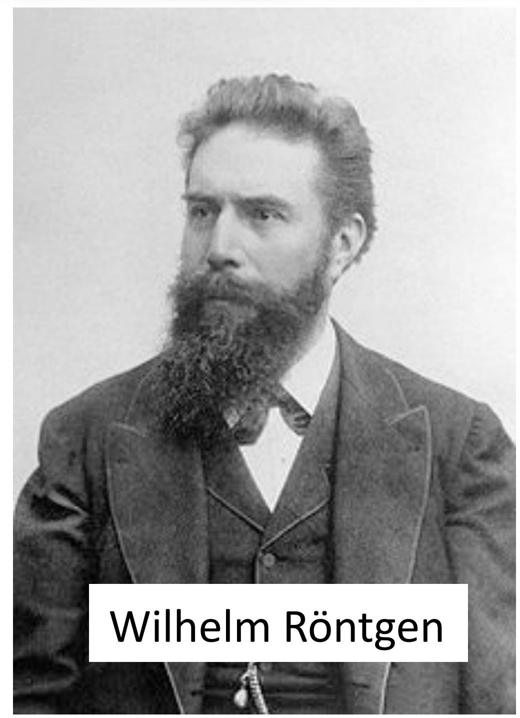


Ultraviolet

- 3 eV to 100 eV
- Photon energies comparable to many chemical reactions. Mostly absorbed by ozone (O_3) in the stratosphere.
- Can damage living tissue
- Can cause materials to fluoresce: raises an electron to a high level, and then it emits its energy by a series of downward jumps, each resulting in the emission of a lower energy photon.

X-rays

- 0.1 to 200 keV.
- Discovered in 1895 by Röntgen
- Tend to interact with inner electrons, nearer the nucleus of atoms: Calcium is a better absorber than Carbon because it has deeper electrons.
- X-ray Astronomy is done with balloons and satellites: looks at stars and galaxies.



Gamma Rays

- Photon Energies above about 0.2 MeV.
- Involved in nuclear reactions.
- Pretty dangerous ionizing particles (along with beta and alpha)
- Some gamma-ray astronomy: Gamma-Ray Bursters are intense, short bursts of gamma rays from extremely distant galaxies