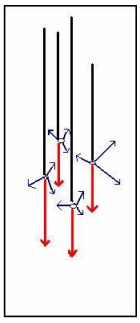
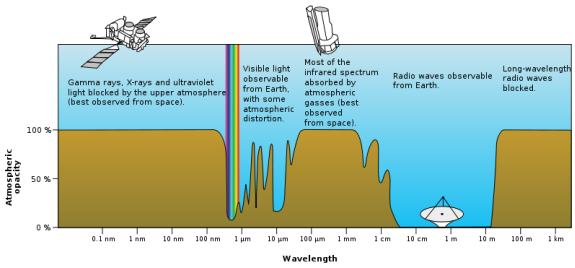
PHY385-H1F Introductory Optics

Class 6 – Outline: Sec. 4.1, 4.2, 4.3

- Handing back Problem Set 1 (marks are on portal)
- Rayleigh Scattering
- Phase lag
- Huygen's Principle
- Reflection of Wave Fronts
- Phase shift upon reflection



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

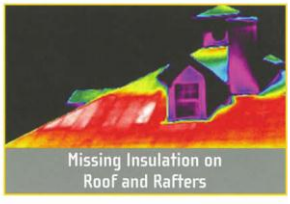
Heinrich Hertz

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.

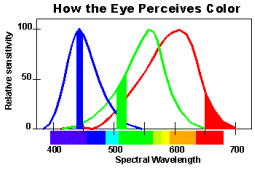
Infrared

- 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.

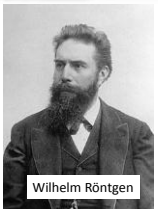


Ultraviolet

- 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.

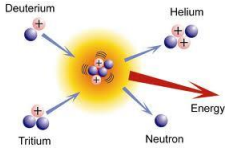
X-rays

- 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.


Wilhelm Röntgen

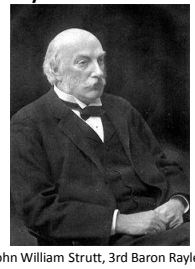
Gamma Rays

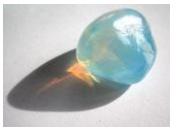
- Photon Energies above about 0.2 MeV.
- Involved in nuclear reactions.
- Pretty dangerous ionizing particles (along with beta and alpha)
- Some gamma-ray astronomy: Gamma-Ray Bursters are intense, short bursts of gamma rays from extremely distant galaxies



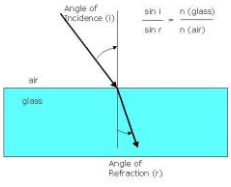
"Daddy, why is the sky blue?"

- Rayleigh scattering is elastic scattering of light by particles much smaller than the wavelength of light.
- Scattering intensity is proportional to λ^{-4}
- So, shorter blue wavelengths are scattered much more readily than longer red wavelengths.
- You see blue light coming from all directions in the sky, as long as there is sunlight passing through the air above you.


John William Strutt, 3rd Baron Rayleigh



Discussion Question

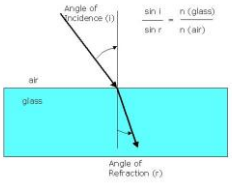


For any wave, it is true that $v = \lambda f$.

Light starts in air, where $n = 1$, and enters glass, where $n = 1.5$.
Upon entering the glass, the speed, v,

1. increases
2. decreases
3. stays the same.

Discussion Question



For any wave, it is true that $v = \lambda f$.

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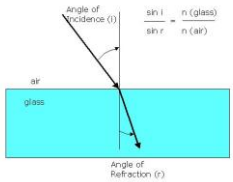
Discussion Question



For any wave, it is true that $v = \lambda f$.

Light starts in air, where $n = 1$, and enters glass, where $n = 1.5$.
Upon entering the glass, the frequency, f

1. increases
2. decreases
3. stays the same.