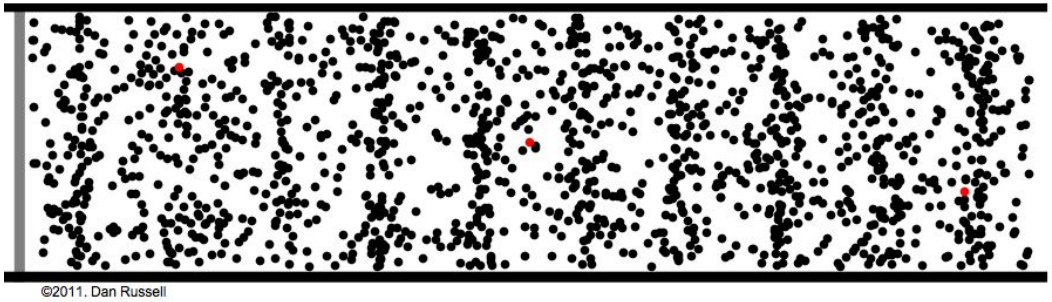
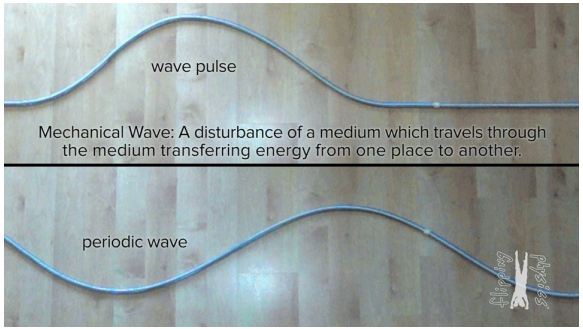
Lasers and Waves

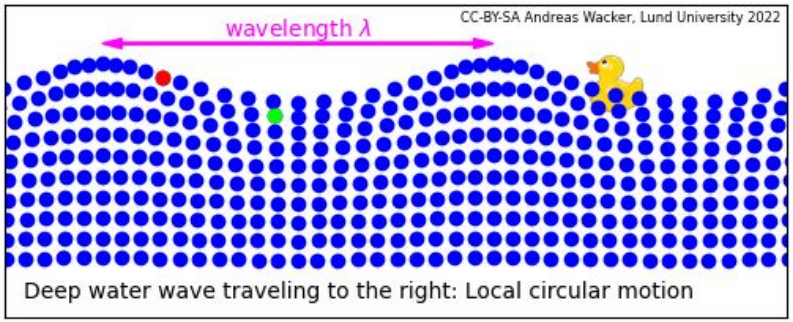
Waves

Oscillations

Waves are oscillations of particles or energy.







Demo: Tub of Water

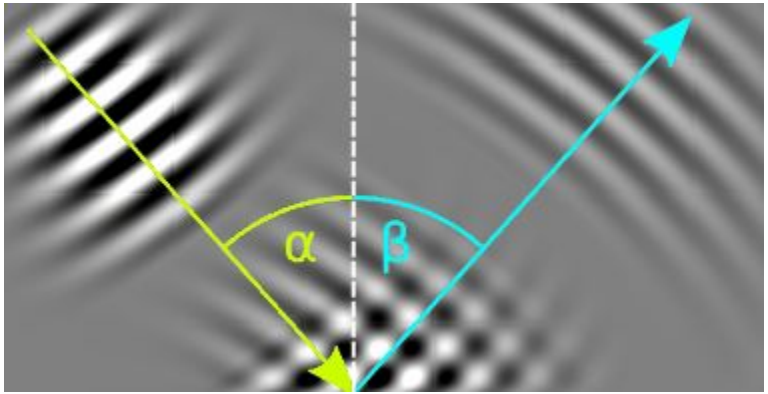
Resonance

Materials are created from vibrating atoms. If you can match the frequency of those vibrations, you have resonance!

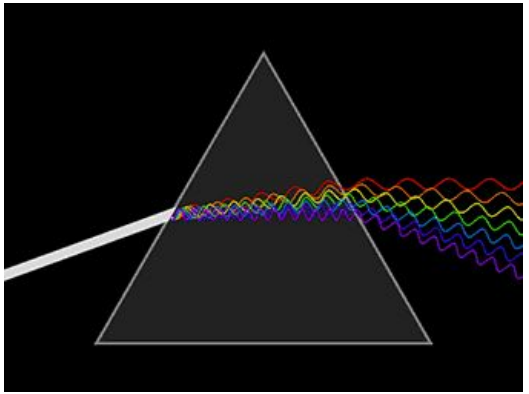
Demo: Household Objects

Reflection and Refraction

Waves, like particles, can bounce off of objects. This bouncing is called reflection.



Unlike particles, waves bend their paths when entering new medium. This is called refraction.



Demo: Rainbow

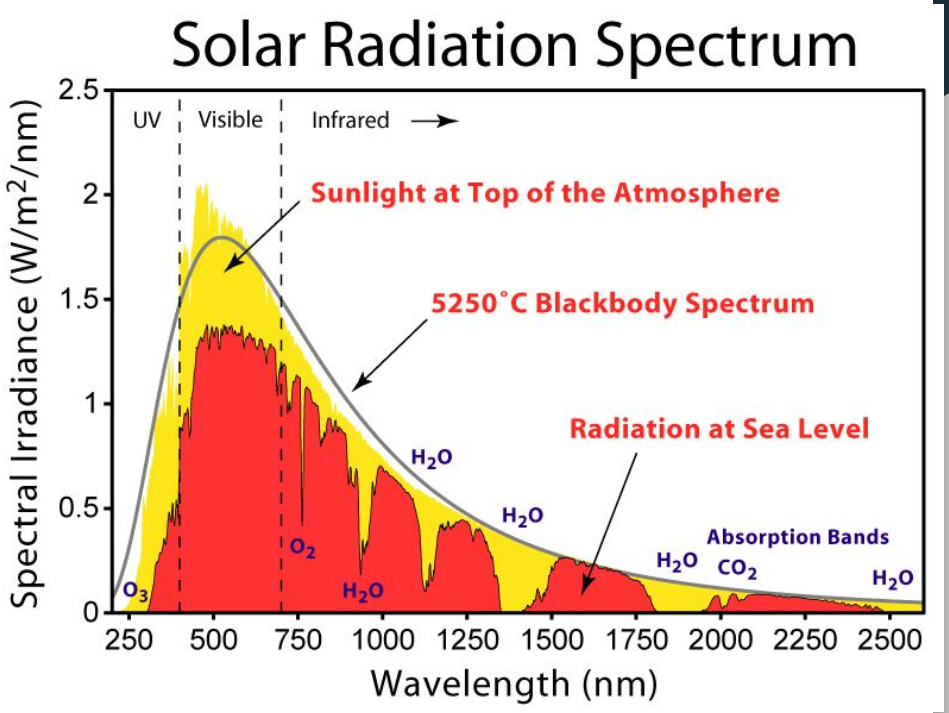
Quantum Mechanics

Blackbodies

If you shine a light on any object, they can either absorb, reflect, or transmit that light.

Blackbodies are only allowed to absorb and re-emit light.

They pretty accurately model celestial radiation, even for our sun!

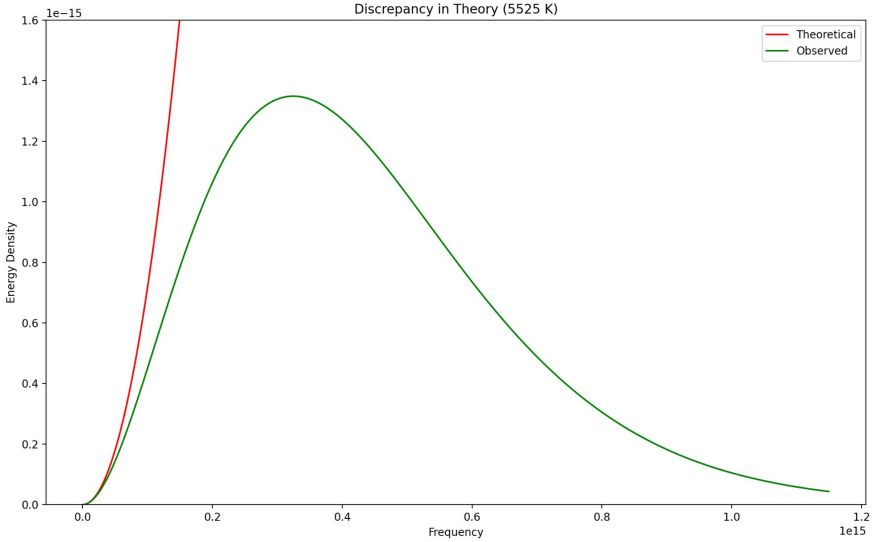


Blackbody Energy

A blackbody gains energy by absorbing light of different frequencies.

How much of the energy is due to light of a specific frequency?

Lord Rayleigh, and later Jeans, came up with an expression that works well for low frequency emissions.



Why does it fail for higher frequencies?

Photoelectric Effect

For decades, people have been using light to blast electrons off of metals.

They noticed higher frequency lights had more success in removing these electrons.

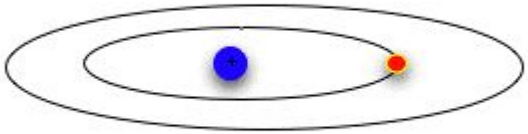
This led to the theory that light was made of particles (photons) whose individual energies were proportional to the frequency of the light.

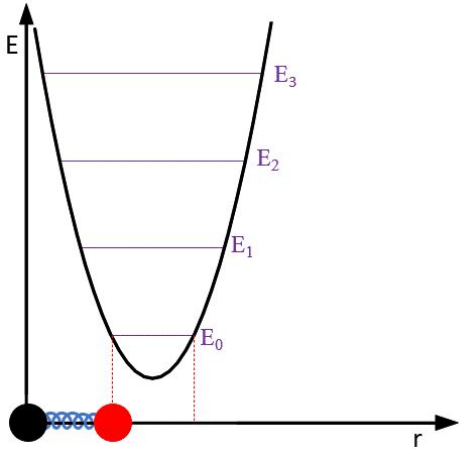
Demo: Tinsel on a Can

Energy Levels

Atoms have discrete energy levels. This means we can count them: 0, 1, 2, 3, etc.

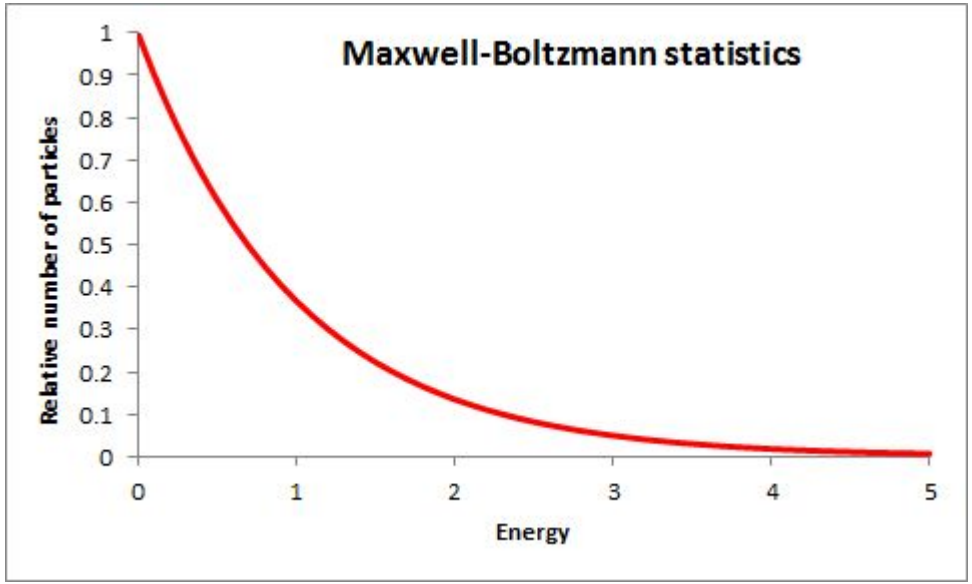
It takes energy to travel to a higher energy level, while travelling to a lower energy level releases energy.





Boltzmann Distribution

Objects want to be in lower energy levels. Boltzmann discovered that the probability of being in a higher energy level is exponentially lower than being in a lower one.

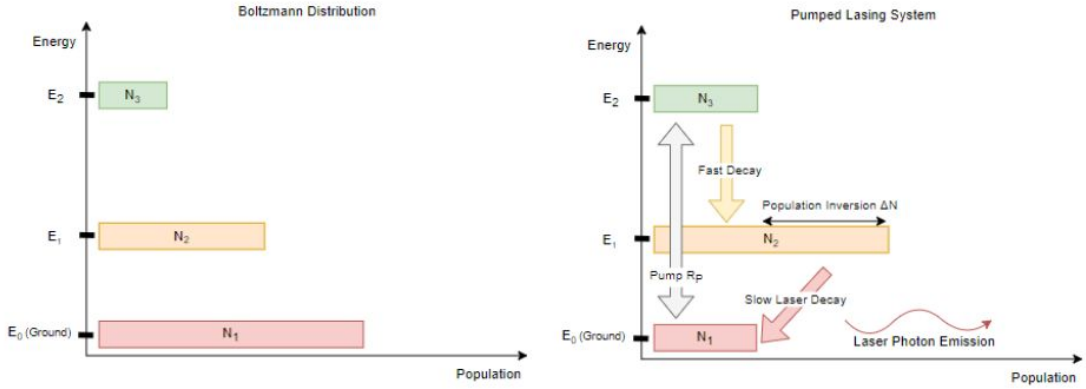


Demo: Coconuts and Castaways

Optics

Lasers

- Early lasers were created by using population inversion. This is where you excite an atom so the higher energy levels are more likely.

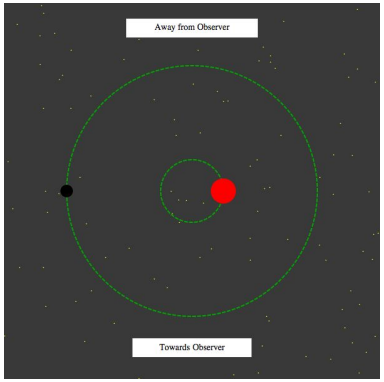


Demo: Diffraction

Doppler Effect

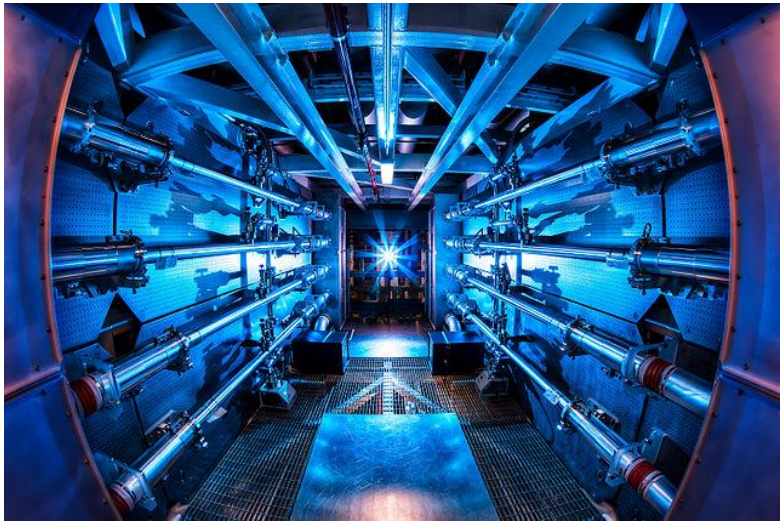
- Sound travelling away from us becomes lower in pitch, this is called the Doppler effect.

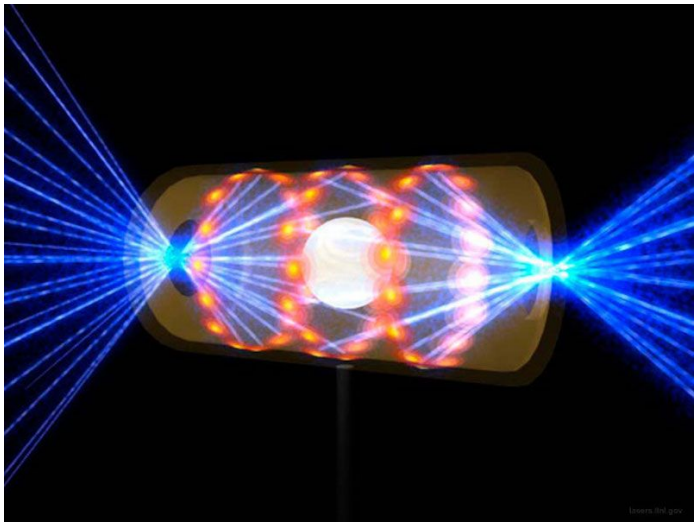
- Light travelling away from us becomes lower in energy (redder), this is called redshift.



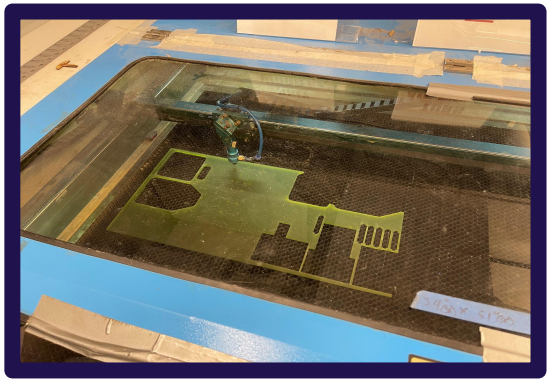
Applications

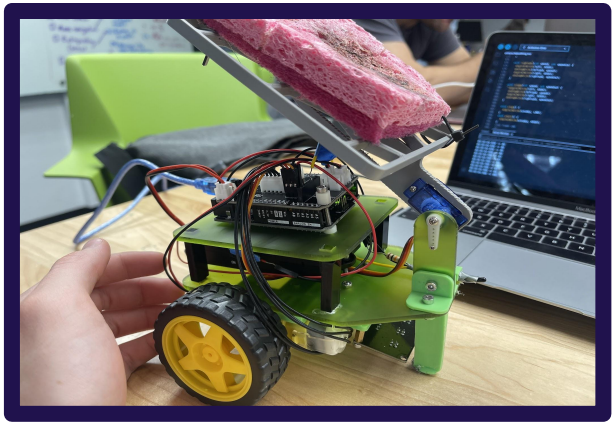
Inertial Confinement Fusion





Laser Cutting





Nonlinear Optics