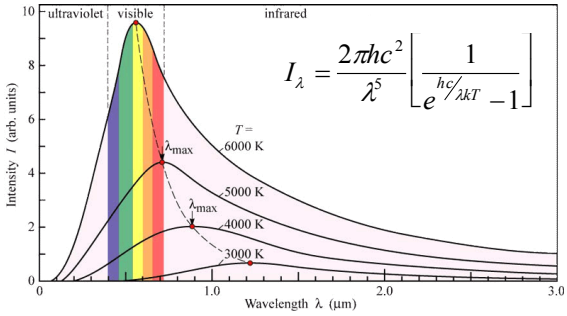
PHY385-H1F Introductory Optics

Class 15 – Outline: Section 13.1

- Population of Electron Energy Levels
- Einstein A and B Coefficients
- Gas Laser; HeNe
- Optical Resonant Cavities
- Transverse Modes
- Gaussian Beams
- Properties of Laser Light
- The Diode Laser

Blackbody Radiation



Stefan-Boltzmann Law

- The filament of a 10-Watt light bulb has a temperature of 1750 degrees Kelvin. If, instead, it is operated at 3500 degrees Kelvin, what will be the power of the bulb?

1. 20 W
2. 100 W
3. 160 W
4. 400 W

Wien's Law

- The maximum wavelength of the spectrum from a 10-Watt light bulb is 1,600 nm (infrared), when its temperature is 1750 degrees Kelvin. If, instead, it is operated at 3500 degrees Kelvin, the maximum wavelength of its spectrum will be

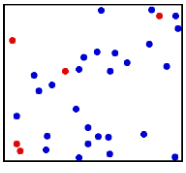
1. 3,200 nm
2. 800 nm
3. 100 nm
4. 400 nm

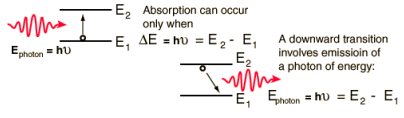
Boltzmann Distribution

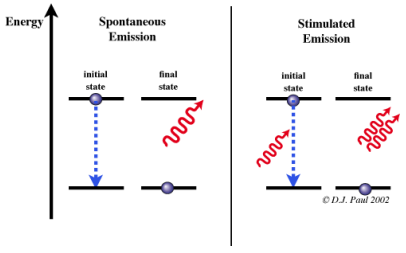
- Consider a tank of Hydrogen gas at room temperature (20 degrees Celsius).
- Hydrogen has a famous red transition $n = 3 \rightarrow 2$ which has a wavelength of 656 nm. (Astronomers call this "H-alpha".)
- What is the ratio N_3/N_2?

In this little animation, the temperature of the Hydrogen gas is 7000 K. Ground state H-atoms are not shown. What do you think?

1. Red dots represent atoms in the n=2 state, blue dots represent atoms in the n=3 state
2. Blue dots represent atoms in the n=2 state, red dots represent atoms in the n=3 state







Einstein A and B Coefficients

- Spontaneous Emission: $\left(\frac{dN_2}{dt}\right)_{sp} = -A_{21}N_2$

A_{21} is the **decay constant** for the 2 → 1 transition with units s^{-1}.

- Absorption: $\left(\frac{dN_1}{dt}\right)_{ab} = -B_{12}N_1u_\nu$

B_{12} is the **absorption coefficient** for the 1 → 2 transition with units [$m\ kg^{-1}$]. u_ν is the radiation density per frequency, with units [$J\ m^{-3}\ Hz^{-1}$]

- Stimulated Emission: $\left(\frac{dN_2}{dt}\right)_{se} = -B_{21}N_2u_\nu$

$B_{21} = B_{12}$