

Photon-Matter Interactions

SCATTERING

- * Rayleigh - elastic $\sim f^4$
- * Compton - continuum
- Raman - discrete

* (previously discussed)

ABSORPTION

- Resonance } B_{12}
- Fluorescence } B_{12}
- * Photoelectric
- * Pair-production

EMISSION

- Spontaneous A_{21}
- Stimulated B_{21}
- MASER
- LASER

Einstein's Coefficients

absorption
spontaneous emission
stimulated emission

$$P/t = B_{12} u(f)$$

$$P/t = A_{21}$$

$$P/t = B_{21} u(f)$$

Fluorescence - high energy photons

→ multiple lower energy

Scintillation - high energy γ -rays or particles

→ UV or visible light.

Phosphorescence - similar to fluorescence

on a longer time-scale.

connection:

a) Boltzmann: $\frac{N_2}{N_1} = e^{-(E_2 - E_1)/kT} = e^{-hf/kT}$

b) dynamic equilibrium: (detailed balance) $N_1 B_{12} u(f) = N_2 (A_{21} + B_{21} u(f))$

$$\rightarrow u(f) = \frac{A_{21}/B_{21}}{B_{12}/B_{21} e^{hf/kT} - 1}$$

c) Planck's law

$$u(f) = \frac{8\pi hf^3/c^3}{e^{hf/kT} - 1}$$

$$\Rightarrow \boxed{B_{12} = B_{21}} \quad \boxed{A_{21} = \frac{8\pi hf^3}{c^3} B_{21}}$$

note: $B_{21} = \frac{\omega^3 n |\mu_{21}|^2}{3\pi \epsilon_0 \hbar c^3}$

$$\hbar\omega = E_2 - E_1$$

n = index refraction

ϵ_0 = permittivity

c = speed of light.

$$\mu_{21} = \int \Psi_2^*(x) \cdot x \cdot \Psi_1(x)$$

"transition matrix element"