Transition

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$$\rho(\nu)d\nu \equiv \frac{8\pi\nu^2}{c^3}\frac{h\nu}{e^{\frac{h\nu}{kT}}-1}d\nu$$

$$dP = \frac{c}{4\pi}\rho(\nu)dAd\Omega\mathrm{d}\nu\cos\theta$$

$$\frac{d}{dt}P_{12} = B_{12}\rho(\nu), \qquad this\ correspodns\ to\ energy\ used\ to\ pump\ states\ from\ 1\ to\ 2, decrease\ fock\ number\ by\ 1$$

$$\frac{d}{dt}P_{21} = B_{21}\rho(\mathrm{v}), \qquad the\ induced\ emission\ of\ photons, results\ in\ increase\ of\ fock\ number\ by\ 1$$

$$\frac{d}{dt}P_{21}^{spon} = A_{21}, \qquad this\ induced\ spontaneous\ emission\ is\ due\ to\ ground\ state\ flucuationas\ field$$

$$N_i(E_i) = N\frac{g_i}{Z}e^{-\frac{E_i}{kT}}$$

$$Z = \sum_i g_i e^{-\frac{E_i}{kT}}$$

$$\sum_i N_i = N,$$

$$N_2[B_{21}\rho(\nu) + A_{21}\,] = B_{12}N_1\rho(\nu)$$

$$\frac{N_2}{N_1} = \left(\frac{g_2}{g_1}\right)e^{-\frac{h\nu}{kT}}, \qquad E_2 - E_1 = h\nu$$

$$\boldsymbol{\rho(\nu) = \frac{A_{21}}{B_{21}}\frac{1}{\frac{g_1}{g_2}\frac{B_{12}}{B_{21}}e^{\frac{h\nu}{kT}}-1}}$$

$$\boldsymbol{B_{12} = \frac{g_2}{g_1}B_{21}}$$

$$\boldsymbol{A_{21} = \frac{8\pi h\nu^3}{c^3}B_{21}}$$

There are 4 spectral densities

W_ν, *radiant energy*
P_ν, *radiant power*
ρ_ν, *spectral densities*
L_ν, *radiance*

$$\boldsymbol{\sigma_{ik} = \pi r_{ij}^2\ for\ |i\rangle\ to\ |k\rangle}$$

$$P_{ik} = I_o \cdot \Delta\nu \cdot \int \alpha_{ij}(\omega)d\omega$$

$$P_{ik} = \frac{\hbar\omega}{c}I_o B_{ik}\left(N_i - \frac{g_i}{g_k}N_k\right)\Delta V$$

$$\boldsymbol{B_{ik} = \frac{c}{\hbar\omega}\int \sigma_{ik}(\omega)d\omega}$$

$$\kappa_i = \frac{N_i e^2}{2\varepsilon_0 m}\sum_k \frac{\omega f_{ik}\gamma_{ik}}{(\omega_{ik}^2 - \omega^2)^2 + \gamma_{ik}^2\omega^2},$$

$$n_i' = 1 + \frac{N_i e^2}{2\varepsilon_0 m}\frac{(\omega_{ik}^2 - \omega^2)f_{ik}}{(\omega_{ik}^2 - \omega^2)^2 + \gamma_{ik}^2\omega^2},$$

In geometry, a **solid angle** (symbol: **Ω**) is the two-dimensional angle in three-dimensional space that an object subtends at a point. It is a measure of how large the object appears to an observer looking from that point. In the International System of Units (SI), a solid angle is expressed in a dimensionless unit called a *steradian*(symbol: sr).

From <https://en.wikipedia.org/wiki/Solid_angle>

$$d\Omega = \sin\theta\, d\theta d\varphi$$