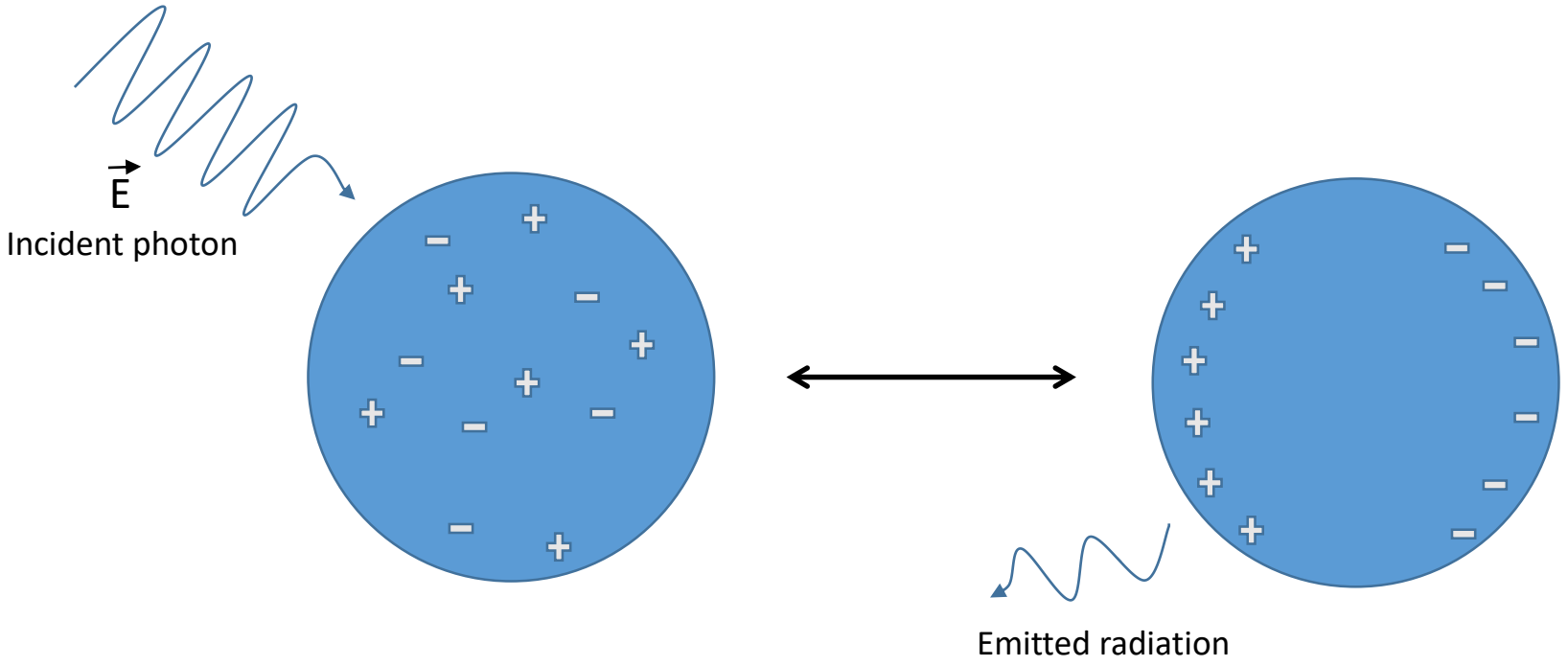
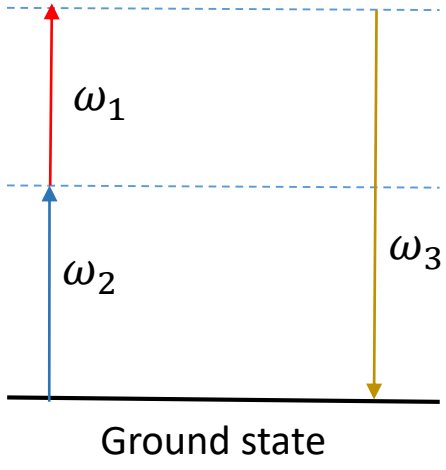
Interaction of radiation with matter

- When light of certain intensity is incident on the molecule it become polarized and when it again returns to initial condition it emits light of frequency that is characteristic of that molecule.



Non-Linear Optical Processes

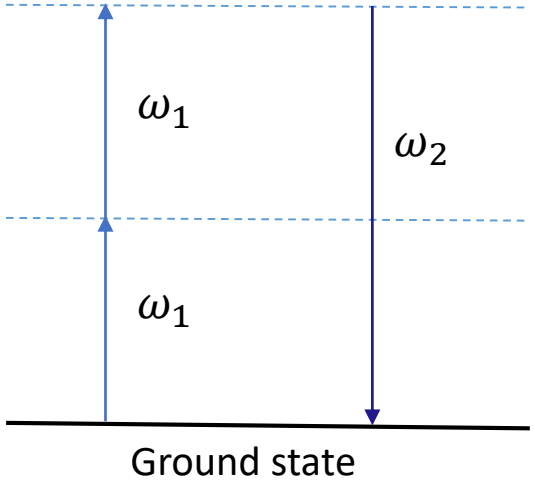
- Polarization process can be considered as excitation of molecule to the virtual state. Depending upon intensity of light used there can be linear scattering, sum frequency generation(SFG), second harmonic generation(SHG), third harmonic generation(THG) and so on…



Virtual states

SFG

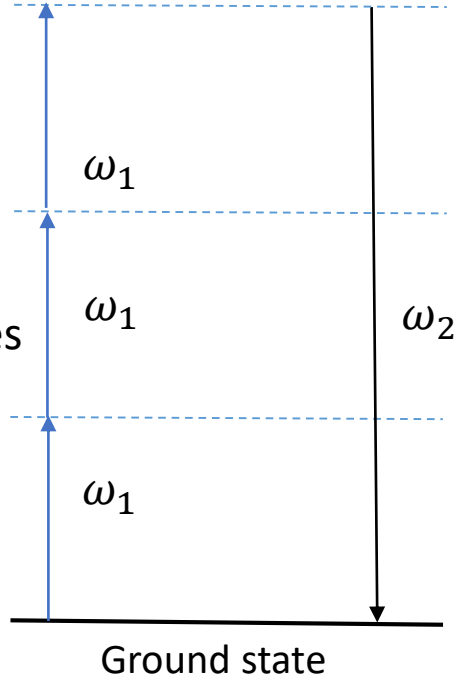
$\omega_3 = \omega_1 + \omega_2$



SHG

$\omega_2 = \omega_1 + \omega_1$

Virtual states



Third Harmonic generation

$\omega_2 = \omega_1 + \omega_1 + \omega_1$

Phase Matching

- Phase matching can be done by synchronization of the phase velocity: $v_{ph} = \frac{\omega}{k} = \frac{c}{\eta}$

ω = frequency, k = wave vector, c = velocity of light in vacuum,

η = refractive index of the medium which is a function of ω.

Now,

$$k_2(2\omega_1) = k_1(\omega_1) + k_1(\omega_1)$$

$$k_3(\omega_3) = k_1(\omega_1) + k_2(\omega_2)$$

where, $\omega_1, \omega_2, \omega_3$ = frequency of fundamental, second harmonic wave and a general wave mixing case respectively.

k_1, k_2, k_3 = wave vectors of fundamental, second harmonic wave and a general wave mixing case respectively.

Condition for Phase Matching

Let us define:- $\Delta k = k_3(\omega_3) - k_1(\omega_1) - k_2(\omega_2)$

For phase matching:- $\Delta k = 0$

$$k_3(\omega_3) = k_1(\omega_1) + k_2(\omega_2)$$

Using, $\frac{\omega_a}{k_a} = \frac{c}{\eta_a}$ or $k_a = \frac{\eta_a \omega_a}{c}$

$$\eta_3(2\omega_1) = \eta_1\omega_1 + \eta_1\omega_1 \text{ or } \eta_3 = \eta_1$$

Since refractive index η is a function of ω so using, $\eta_3 = \eta(2\omega_1)$ and $\eta_1 = \eta(\omega_1)$

$$\eta(2\omega_1) = \eta(\omega_1)$$

This equation referred as the index matching condition .