Light in Matter

The electric field distorts the charge distribution in the dielectric by generating dipoles that transiently increase the total E field in the medium. The medium is polarized by the light. The degree of polarization depends on the material and E_0

$$P = (\varepsilon - \varepsilon_0)E = \varepsilon_0 \chi E = \varepsilon_0 (n^2 - 1)E = \alpha E$$

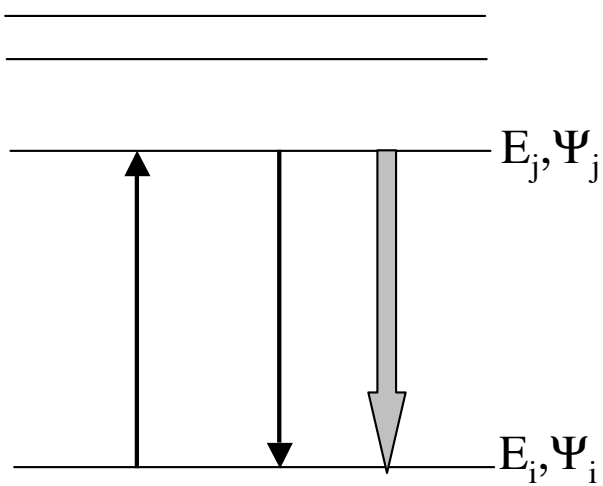
χ: susceptibilty
α: polarizability

The incident radiation induces a small vibration in the electron cloud that oscillates with the EMR, so the electrons behave like a forced (driven) oscillator:

Light-Matter Interactions

What happens when photons encounter matter?

QM: If photon E (hν) is equal to ΔE between states -



$$R_{ij} = \int \psi_i^* \mu \psi_j d\tau$$

in atoms:

$$\bar{\varepsilon} = \frac{8\pi^3 N R_{ij}^2 \nu_{\max}}{6909 hcg_i}$$

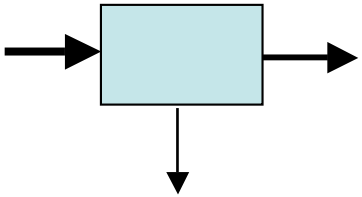
X-rays		
UV		
Visible		
IR		
μ & radio waves		

Non-linear Processes

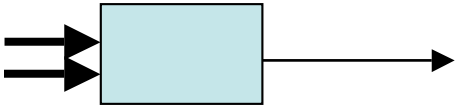
$$\vec{P} = \varepsilon_0 \chi^{(1)} \vec{E} + \varepsilon_0 \chi^{(2)} \vec{E}\vec{E} + \varepsilon_0 \chi^{(3)} \vec{E}\vec{E}\vec{E} + \ldots$$

Intense beams induced higher order interactions in anisotropic materials. SHG requires crystals such as KH_2PO_4 (KDP), $NH_4H_2PO_4$ (ADP), BBO

Linear spectroscopy:



2nd order spectroscopy:



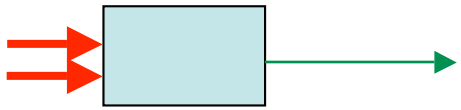
3nd order spectroscopy:

Frequency Mixing

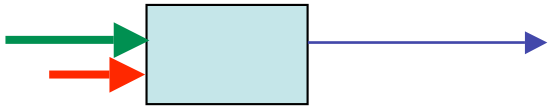
$$\vec{P} = \varepsilon_0 \chi^{(1)} \vec{E} + \varepsilon_0 \chi^{(2)} \vec{E}\vec{E} + \varepsilon_0 \chi^{(3)} \vec{E}\vec{E}\vec{E} + \ldots$$

Intense beams induce higher order interactions in anisotropic materials. SFG/DFG are generalizations of SHG; require crystals such as KH_2PO_4 (KDP), $NH_4H_2PO_4$ (ADP), BBO

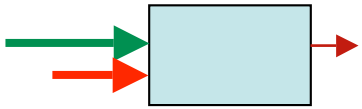
Frequency doubling (SHG)



Sum frequency generation



Difference frequency generation



Parametric Generation

Non-linear Processes

The optical polarization, P, measures the coupling of the radiation field to the material

$$\mathbf{k}_s = \pm\mathbf{k}_1 \pm \mathbf{k}_2 \pm \mathbf{k}_3 \ldots \pm \mathbf{k}_n$$

$$\omega_s = \pm\omega_1 \pm \omega_2 \pm \omega_3 \ldots \pm \omega_n$$

n	Class	Examples	Phase Conditions
1	Two-wave mixing:		
2	Three-wave mixing		
3	Four-wave mixing		