2^{nd} Order Optical Nonlinearity

- Second Harmonic Generation
- Sum Frequency Generation
- Difference Frequency Generation
- Parametric Conversion

- Electric field associated with a plane wave LASER beam

$$E(r,t) = E(\omega_1,k_1)\, e^{i(k_1 r - \omega_1 t)} + E^*(\omega_1,k_1)\, e^{-i(k_1 r - \omega_1 t)}$$

$$= 2E(\omega_1,t)\cos(k_1 r - \omega_1 t)$$

$= E_0 \cos(k_1 r - \omega_1 t)$ (induced polarization at frequency 2ω)

Now putting this value in

$$\mathbf{P}^{(2)} = \boldsymbol{\chi}^{(2)}_{ijk}\, \mathbf{E}_j\, \mathbf{E}_k$$

$$= \boldsymbol{\chi}^{(2)}_{ijk}(0)(E_0^2/2) + (1/2)\,\boldsymbol{\chi}^{(2)}_{ijk}(2\omega_1,2k)E_0^2\cos(k_1 r - \omega_1 t)$$

First term is frequency independent DC effect and 2nd term corresponds to 2nd order/ SHG wave.

- Fundamental and SHG wave can pass through in and out of phase through the material, however out of phase movement leads to a very low intensity of SHG.
- We need to create a synchronization between fundamental and SHG wave, this synchronization is called as phase matching.