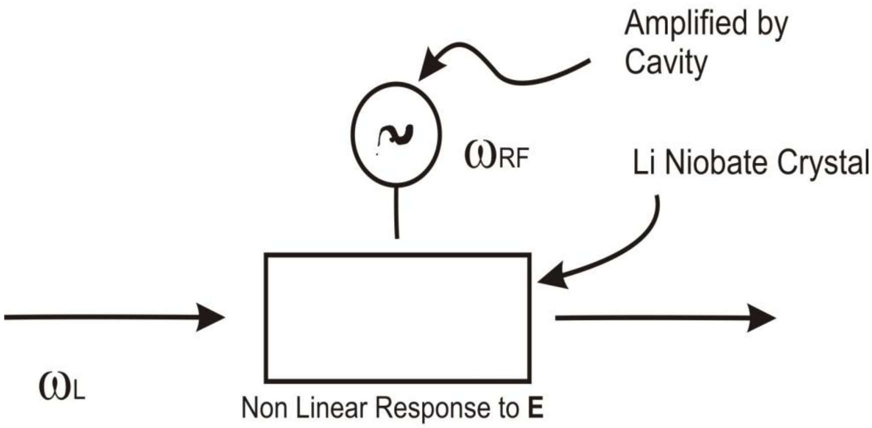
Phys 4061/5061 – Tutorial Seven

Details Pertaining to laboratory experiments covered in this tutorial can be found in the lab manual under the following sections

1. Absorption Emission Spectroscopy / EOM

EOM

Phase Modulator

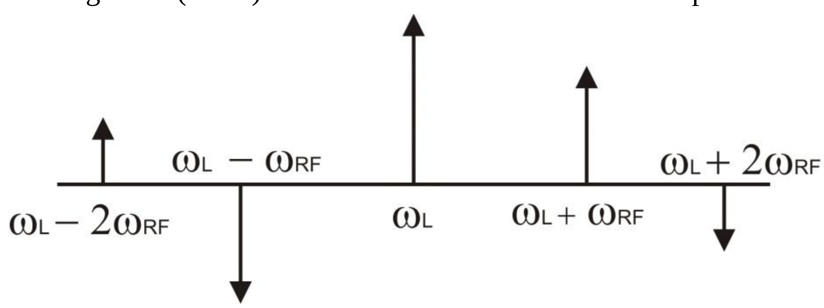


ω_L

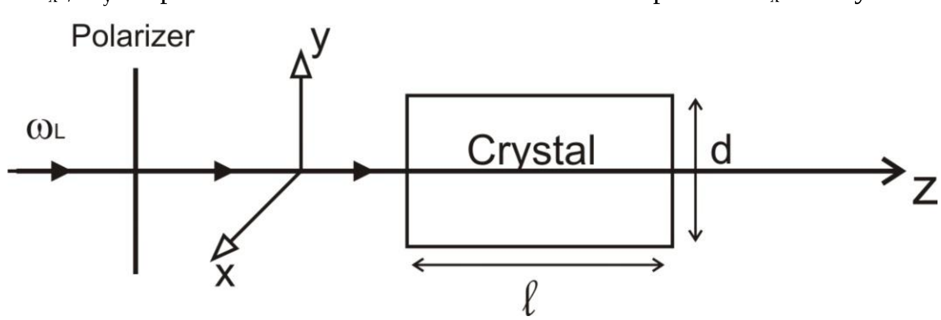
$\omega_L \pm \omega_{RF}$ - Frequency Sideband

$\omega_L \pm 2\omega_{RF}$ - Frequency Sideband

- E(t) responds to changes in n(index) modulated in sinusoidal manner => phase modulations



$n_x \neq n_y$ => phase difference between two E field components E_x and Ey



Phase Difference

- quantified by M, the index of modulation
- it is a property of the crystal

$$M = \left(\frac{\pi l n^3 r_x}{2d\lambda}\right) V_{cap}(t)$$

n= unperterbed index of refraction of the crystal

r_x = electro optic coefficient (depends on crystal symmetry)

$V_{cap}(t)$ = voltage across crystal

λ = wavelength of incident light

d = distance between detectors

ℓ = crystal length

$$E_{output}(t) = E_o\cos(\omega_L t + \varphi(t))$$

- the phase is modulated because the index is modulated

$$\varphi(t) = M\sin(\omega_{RF} t)$$

- M is the amplitude of the phase modulation

$$\frac{E_{output}(t)}{E_o} = \cos(\omega_L t) - \left(\frac{M}{2}\right)\cos(\omega_L - \omega_{RF})t + \left(\frac{M}{2}\right)\cos(\omega_L + \omega_{RF})t$$

- upper sidebands in each order 180 degrees our of phase
- only first sidebands survive for $M<<1$

General Case

$$E(t) = E_o \sum_{-\infty}^{\infty} J_m(M)\exp[it[\omega_L + M\omega_{RF}]]$$

- $J_m(M)$ is the relative amplitude of sideband given by Bessel function, order m

Applications

- communication ~ 40 GHz bit rates
- Repump laser – Atom Trapping
- Frequency Locking by using EOM in sidearm