Photorefractive Optics for Information Storage and Wavefront Correction

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Research activities

- Wavefront sensing and correction
- Information storage and image processing
- Photon counting detectors

Plan……….

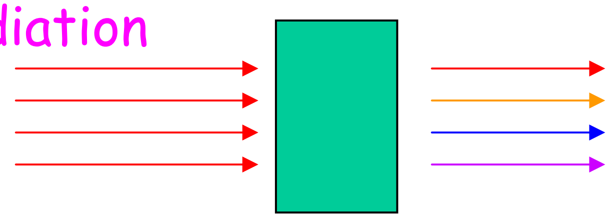
- Nonlinear Optics
- Photorefractive Effect
- Optical Phase Conjugation
- Experiments
- Results

Optical Nonlinearity

Nonlinearity results from the anharmonic response of the bound electrons of the medium to the intense radiation field

Incident Radiation

$E(\omega)$



Induced polarization

$P(\omega)$, $P(2\omega)$, $P(3\omega)$, ...

$$P = P^{(1)} + P^{(2)} + P^{(3)} + \ldots$$

$$= \varepsilon_o \chi_{ij}^{(1)} E_j + \varepsilon_o \chi_{ijk}^{(2)} E_j . E_k + \varepsilon_o \chi_{ijkl}^{(3)} E_j . E_k . E_l + \ldots$$

Susceptibility tensors

$$\frac{|\chi^{n}|}{|\chi^{n-1}|} \approx \frac{1}{|E_o|}$$

Relative magnitude

$$\frac{|P^{(n)}|}{|P^{(n-1)}|} \approx |E| . \frac{|\chi^{n}|}{|\chi^{n-1}|} \approx \frac{|E|}{|E_o|}$$

Strength of optical field

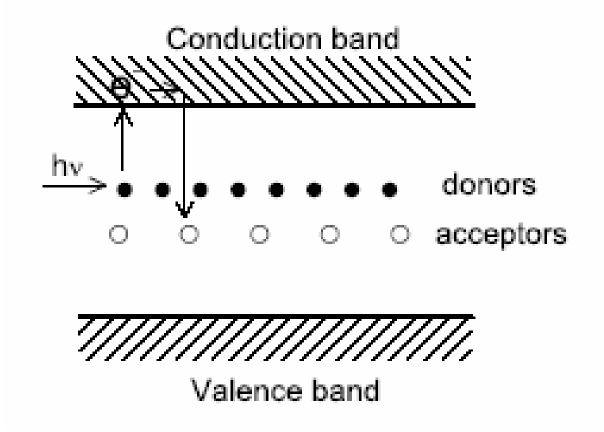
Ave. E-field inside the atom

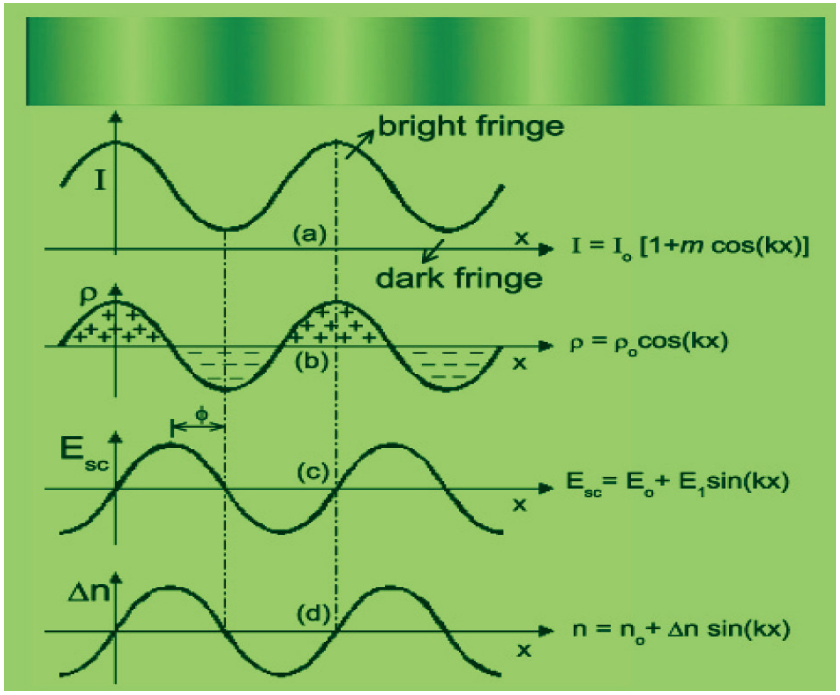
Photorefractive Effect

Change in refractive index of material using light

- presence of inter band impurity atoms (donor/acceptor) in crystal is responsible for PR effect.
- photo-excitation of charges from impurity centers to CB.
- charge migration via drift or diffusion in CB.
- charge re-trapping at ionized impurity sites.
- Spatial re-distribution of charges between brighter and darker regions leads to the development of electrostatic field within the crystal.
- modulation of refractive index takes place via electro-optic effect

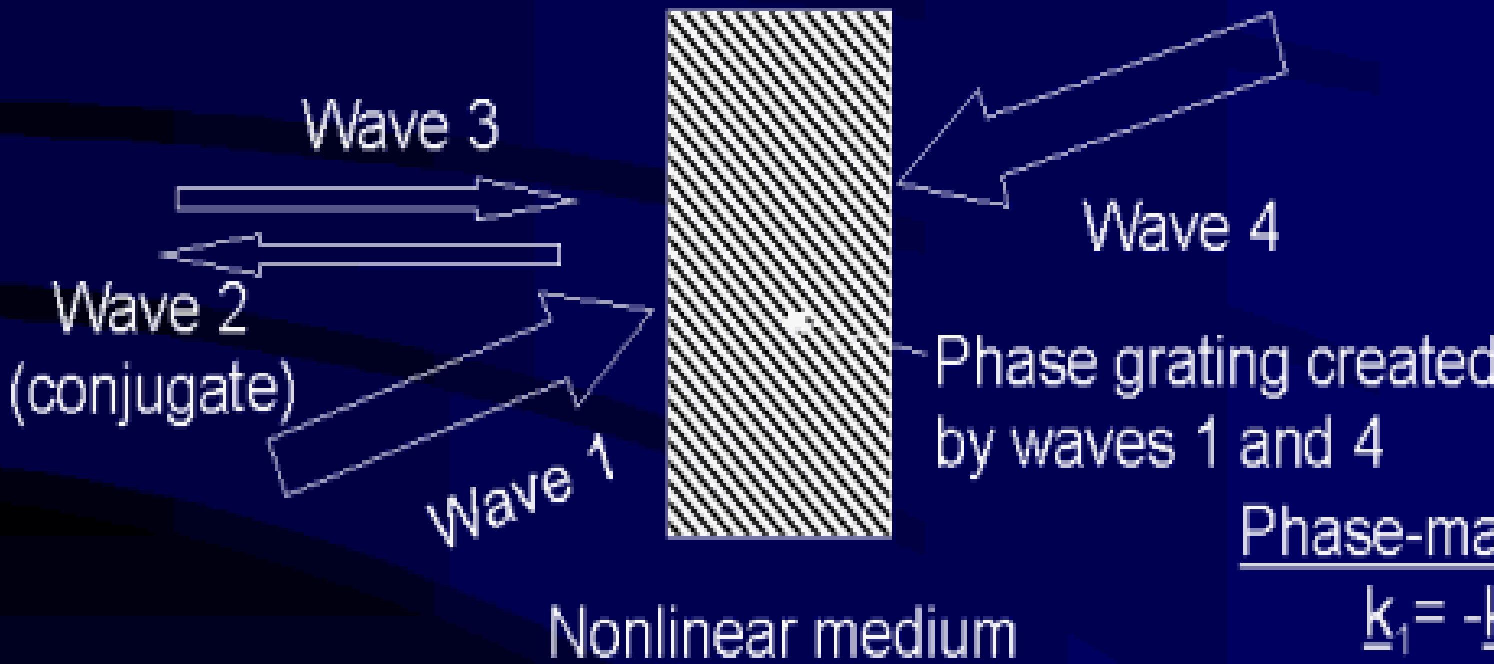
$$\Delta n = -\frac{1}{2} n^3 r_{eff} E_{sc}$$





Optical phase conjugation

- An optical phase conjugator can be used to unravel distortions that occur in passing through a distorting medium
- Optical phase conjugation occurs when we have four wave mixing with all four waves of the same frequency



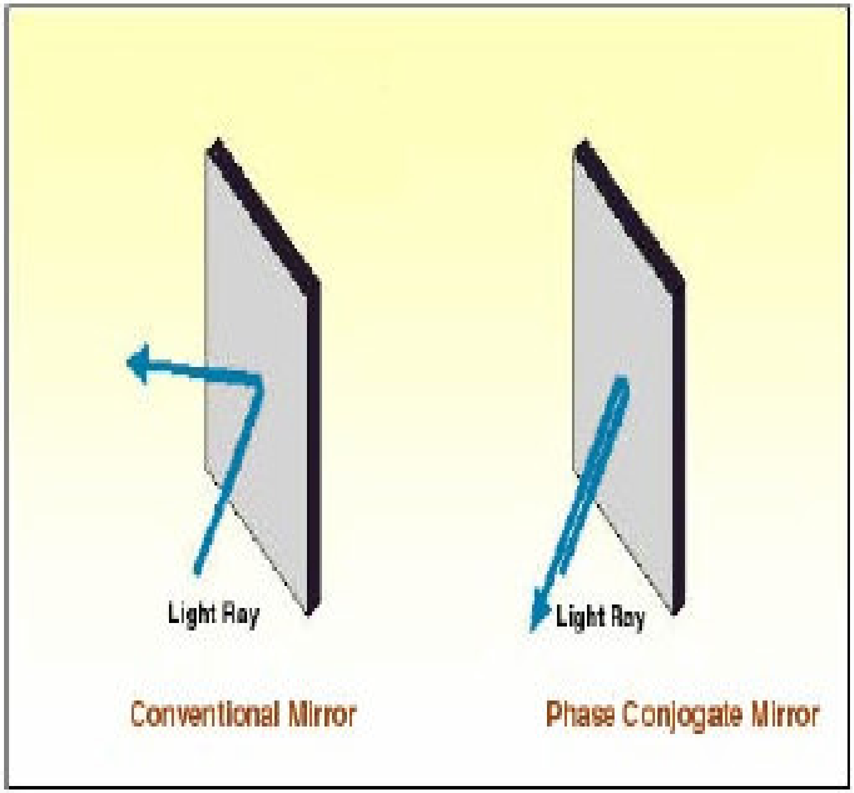
Phase-matching

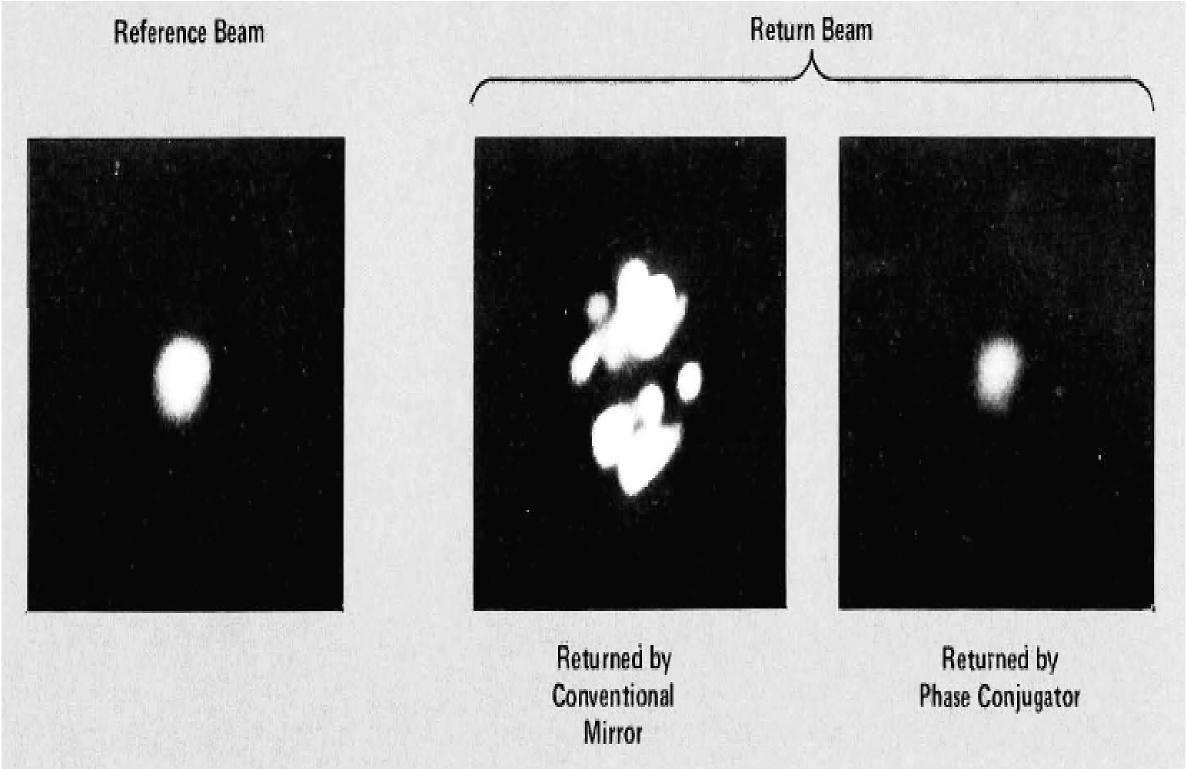
$\underline{k}_1 = -\underline{k}_4$

$\underline{k}_2 = -\underline{k}_3$

Optical Phase Conjugation

- Four wave Mixing (FWM)
- Self pumped phase conjugation (SPPC)
- Stimulated Scattering Process (SBS, SRS etc.)





OPC-FWM

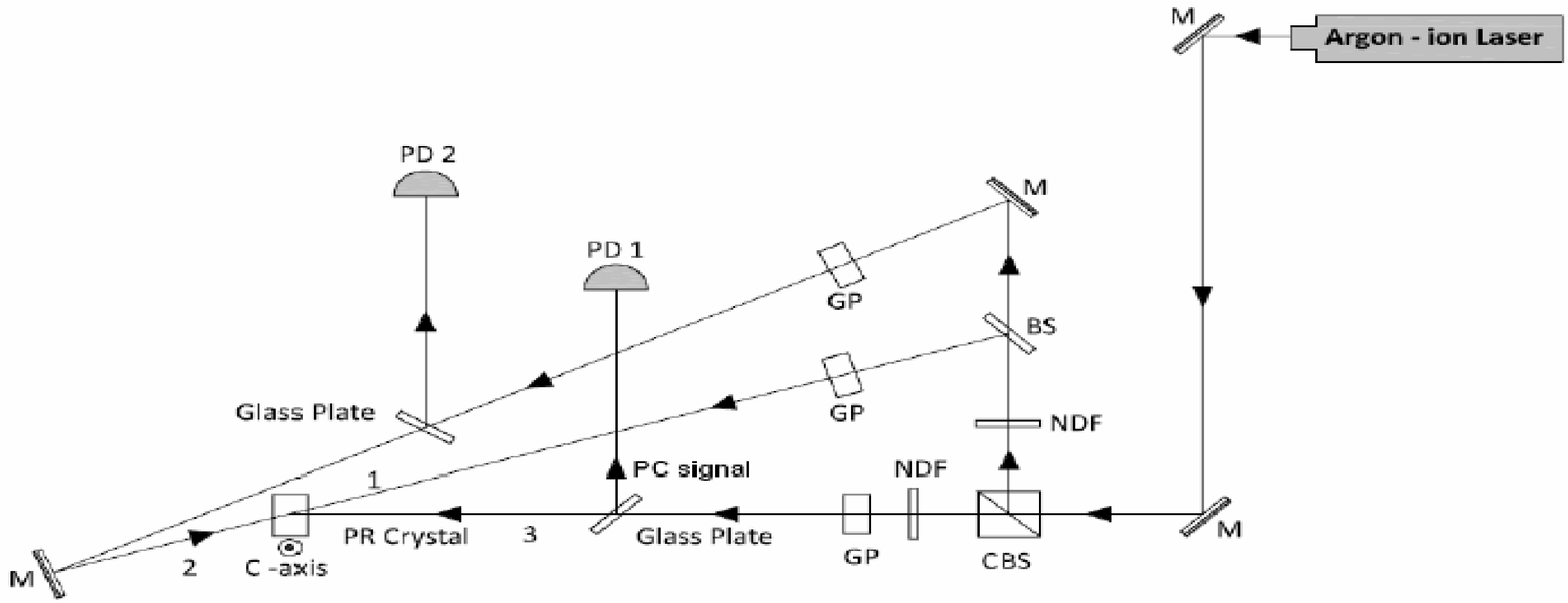


Figure 2.3: Experimental arrangement for DFWM. M-mirror, CBS-cube beam splitter, NDF-neutral density filter, BS- beam splitter, GP-Glan polarizer, PD_1, PD_2-Photodetectors

Diffraction efficiency by TWM

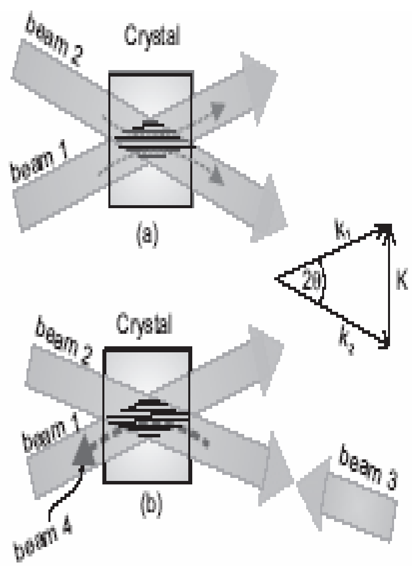
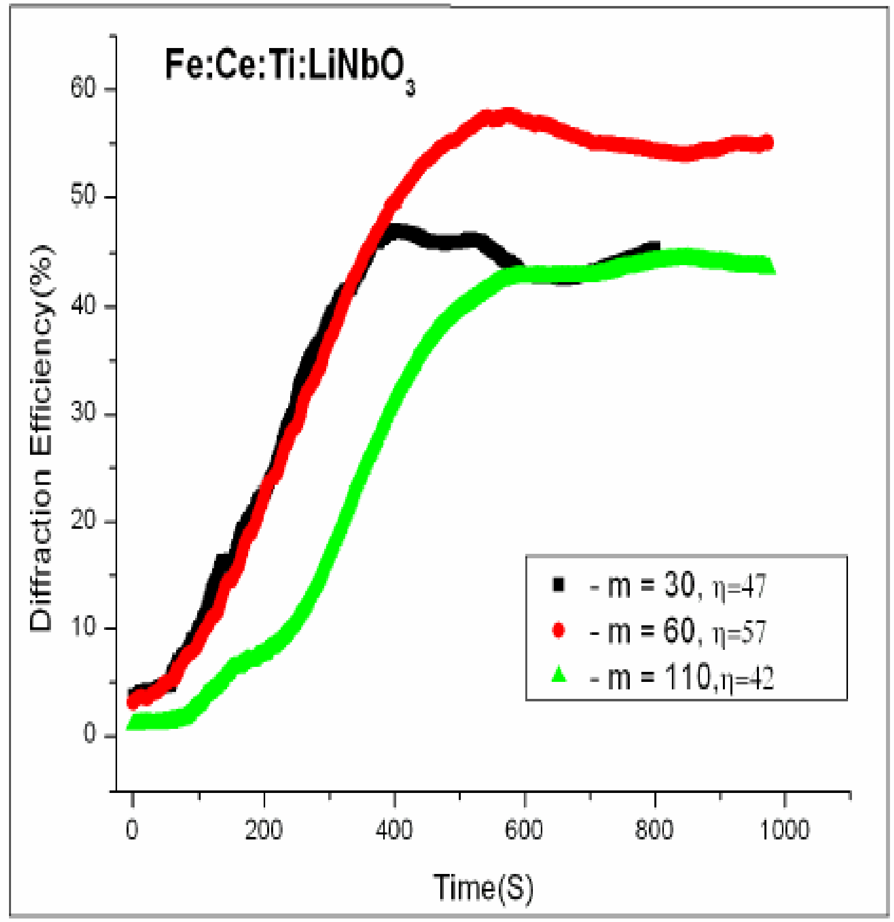


Figure 1.3: Transmission geometry of wave mixing in PR crystal. (a) Two-wave mixing and (b) generation of phase conjugate beam in four-wave mixing.



OPC-SPPC

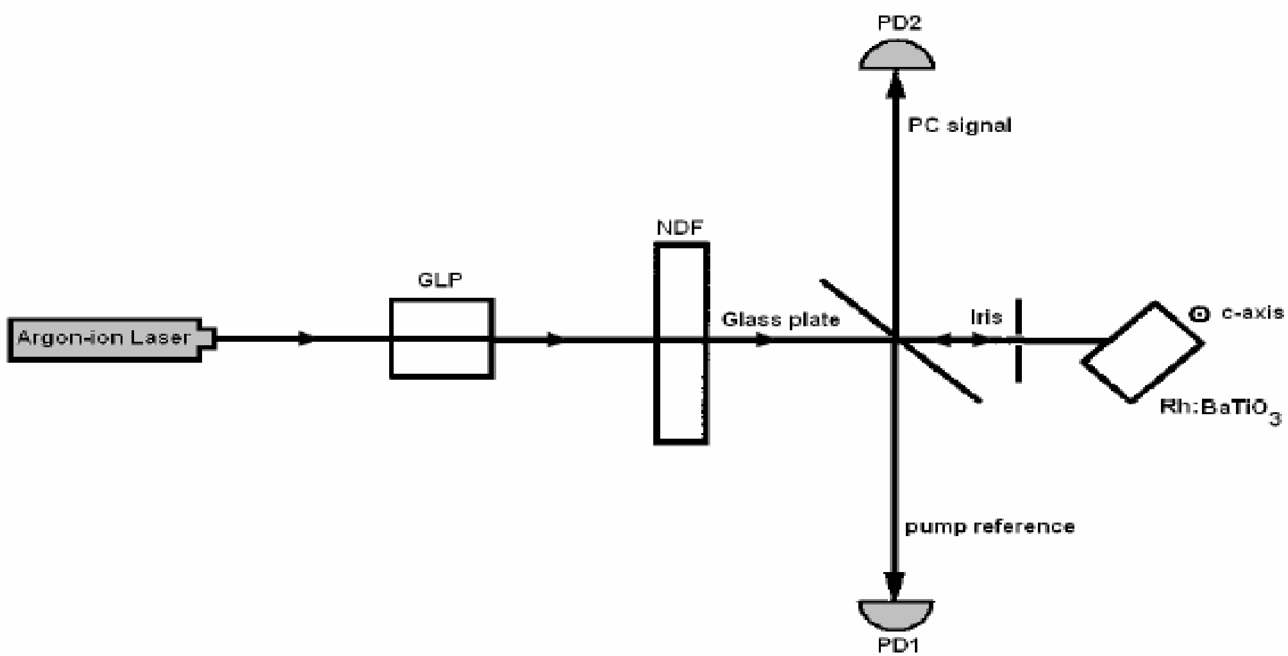
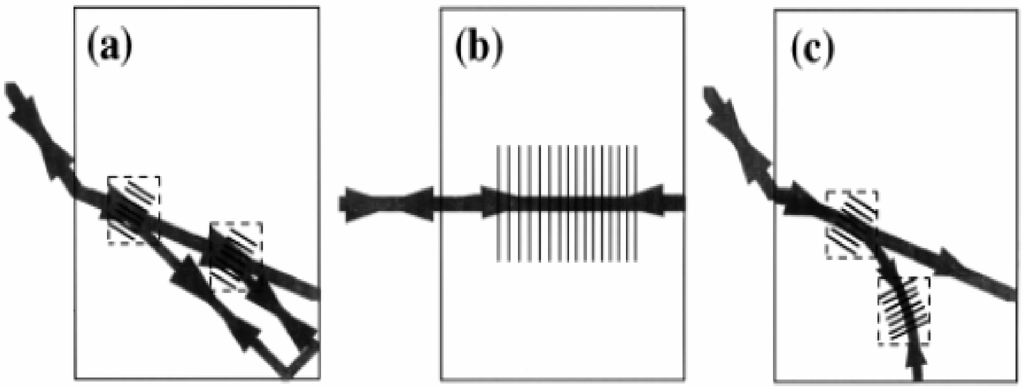


Figure 3.2: Schematic of the SPPC experiment: GLP- Glan polarizer; NDF-Neutral Density Filter; PD1, PD2- Photodeters

Modes of SPPC



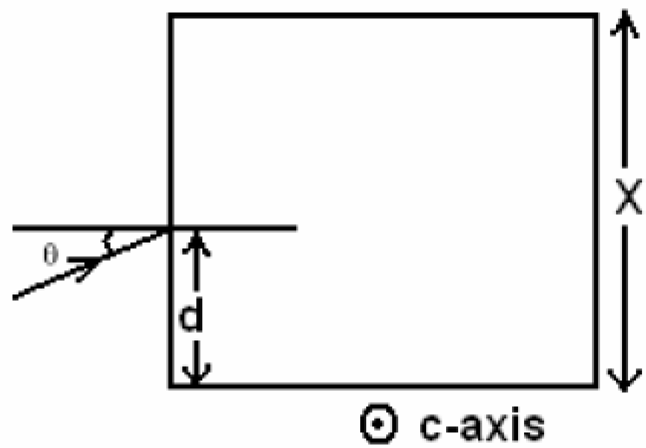
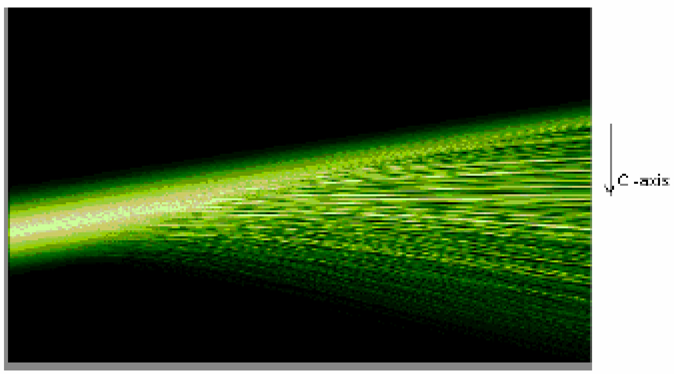
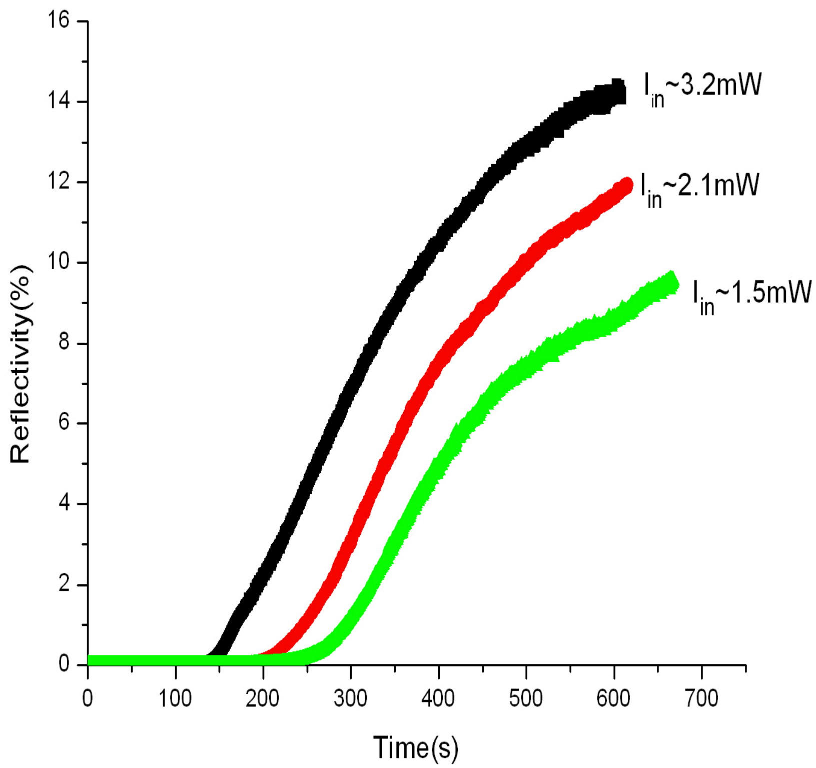


Figure 3.1: Different modes of SPPC: (a) FWM-TIR, (b) SPB, and (c) FWM-SPB.

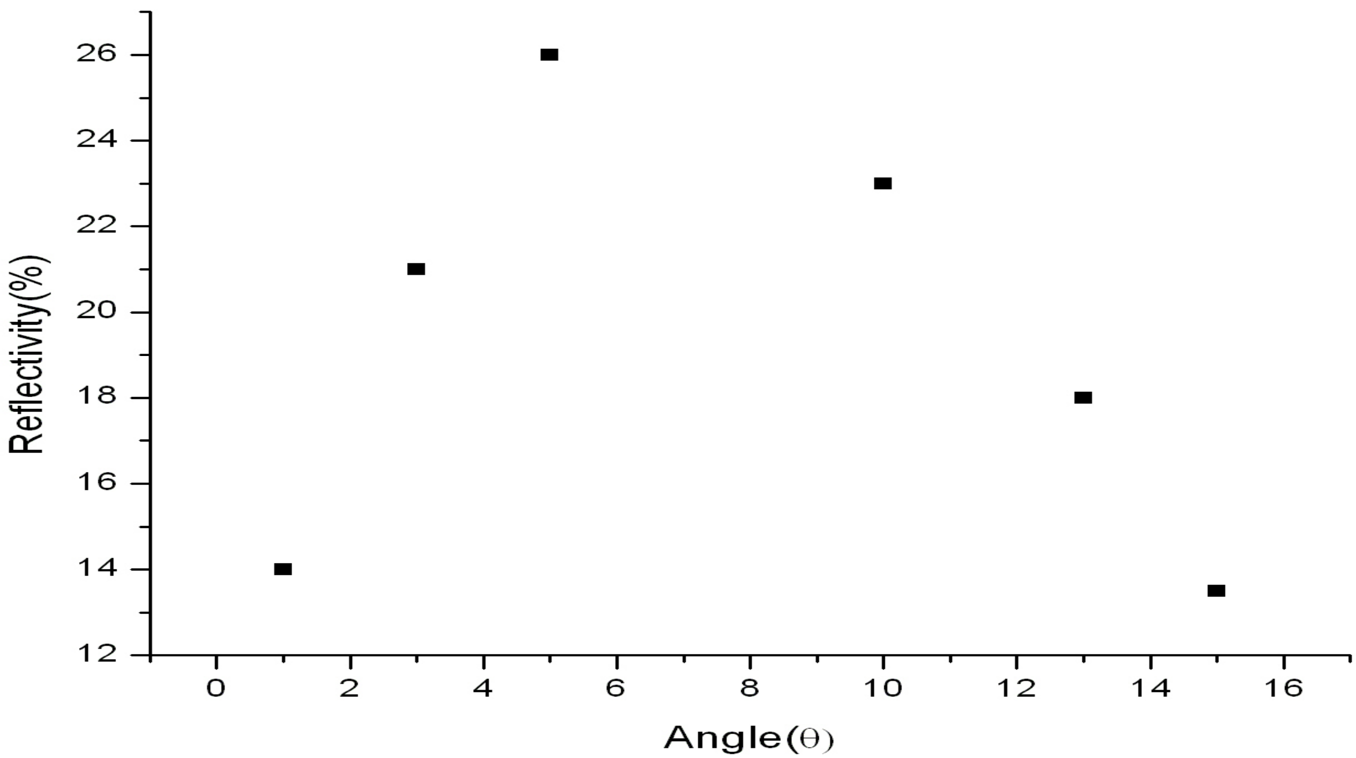


SPPC Reflectivity……

Rh:$BaTiO_3$



Angle dependence……..



credit goes to………

- Ravi Banyal
- Praseetha
- Misha
- Priya

- Vyas

and finally…….

- **Ravinder Kumar Banyal & B. Raghavendra Prasad, High contrast all-optical switching in bacteriorhodopsin films, *Applied Optics*, 44, 5497-5503 (2006).**
- **Ravinder Kumar Banyal & B. Raghavendra Prasad, Measurements of photoinduced refractive index changes in bacteriorhodopsin films, *Pramana – Journal of Physics*. Vol. 68(3), 435-443, 2007.**
- **Ravinder Kumar Banyal and B. Raghavendra Prasad, "Holographic recording in Fe:Ce:Ti doped LiNbO3 crystal" , Optics Communications (in press), OPTICS_4130.**