eyes and sensors against damage by exposure to sudden high intensity light, which still remains a challenging problem. Investigations on the nonlinear absorption, nonlinear refraction and optical limiting (OL) response of the organic chromophore, neutral red (NR) under nanosecond pulsed laser light irradiation at 532 nm was studied. NR (3-amino-7-dimethylamino-2-methyl phenazine) is a low cost organic dye which finds many applications in biology. Z-scan experiments and nonlinear transmission measurements were carried out to investigate the NLO properties and OL behaviour, respectively, of the dye chromophore.

The Z-scan experiments were conducted employing frequency doubled pulsed Nd:YAG laser light (532 nm, 30 ns) with a repetition rate of 1 Hz in a 1 mm quartz cuvette. Both closed and open aperture Z-scan measurements were performed, simultaneously. Optical limiting experiments were also preformed with NR solution. Fig.L13.1 illustrates the open aperture Z-scan data, of NR solution in methanol (linear transmission 20 % at 532 nm). At a peak incident laser intensity of 130 MW/cm^2, the spot size of the beam being ~ 35 μm, it exhibits an interesting behaviour. The sample shows saturable absorption behaviour away from focus and reverse saturable absorption behavior near the focus. To estimate the saturation intensity and the nonlinear absorption coefficient, the experimental data was fitted with numerical simulations and is shown by solid line. Theoretical fit gives saturation intensity, I_s = 18 MW/cm^2 and two photon absorption (TPA) coefficient, β = 110 × 10^{-8} cm/W. Estimated β value in NR solution is very large compared to recently reported β values in various dyes viz., Rubrene, Eosin, Pryridin1, Fluorescein 27, Rhodamine 6G and Rhodamine B

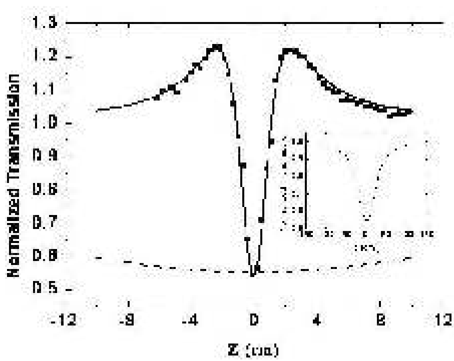

Fig.L.13.1: Open aperture Z-scan experimental data (squares) of NR solution in methanol at I_0 = 130 MW/cm^2. Solid line shows theoretical fit to the experimental data. Dashed line shows theoretical curve considering excited state absorption. Inset shows dashed curve for large Z-values.

Further, attempt was made to fit the experimental data with excited state absorption to rule out its possibility. For excited state absorption, rate equations were solved to estimate the magnitude of the excited state absorption cross-section (σ_2). Dashed line shown in Fig.L.13.1 was generated for the excited state absorption cross-section σ_1 = 9.2 × 10^{-17} cm^2,σ_2 = 13.25 × 10^{-17} cm^2 and β = 0, to match the dip in the transmission of the experimental data. The theoretically estimated complete normalized transmission curve does not appear within the experimentally used Z-values. The complete dashed curve is shown in the inset of Fig.L.13.1 and was generated with Z values much larger than that used in the experimental data. Obviously, the dashed curve does not fit to the experimental data. The saturation of absorption is also included in the analysis, but no peak is observed in the transmission curve. Therefore, it was concluded from the analysis that the dominant mechanism of nonlinear absorption in neutral red dye is TPA.

The estimated value of nonlinear refractive index, n_2 of the sample by fitting closed aperture Z-scan data was found to be 1.5 × 10^{-12} cm^2/W, while in the solid film form, it was 4.0 × 10^{-9} cm^2/W. The larger value of n_2 in the solid form of NR sample may be due to the greater concentration of NR dye molecules in the solid film (~ 10^{-2} mol/L) compared to the solution (~ 10^{-4} mol/L). The observed optical limiting of nanosecond laser pulses at 532 nm showed that, neutral red, which has a limiting threshold lower than that of C_{60}, is a good optical limiter. Moreover, the simultaneous occurrence of several nonlinear processes in this dye, signifies the possibility of utilising it in photonic device applications.

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L.14 : Polarization dependence of quadratic photocurrent in light emitting diodes

Semiconductor devices like photo-diodes, laser diodes, light emitting diodes etc. have drawn considerable interest in recent years as simple, easy to use, and inexpensive substitute for second harmonic generation (SHG) based non-linear crystals for several applications like autocorrelation measurements of ultra short laser pulses, ultra high-speed optical communication, microscopy etc. Knowledge of the polarization dependence of the induced quadratic photocurrent in the former is essential in certain applications such as polarization-insensitive cross correlation measurements or fringe-free cross-polarized autocorrelation (CP-AC) used in collinear optical geometry for microscopy. Although the exact physical process responsible for quadratic photocurrent in light emitting diodes (LED) is not known precisely, it is generally assumed to be due to the two-photon absorption (TPA) process in the semiconductor material. The quadratic photo-response of such devices may also occur due to SHG either in bulk LED material (GaAs) or at the asymmetric interfaces, even for centro-symmetric materials. At Laser Plasma Division of RRCAT, polarization dependence of the quadratic photo-current in AlGaAs based LEDs and characteristics of CP-AC signals have been studied to distinguish the two processes, using a 200 fs duration laser beam from a cw mode-locked laser oscillator.

Typical induced photocurrent of the AlGaAs LED recorded w. r. to the angle of rotation of the half wave plate is depicted in Fig.L.14.1a. It is seen that the induced current changes periodically with orientation of linear polarization of the laser beam. Next, the CP-AC signals have been recorded using modified Michelson interferometer. A properly oriented quarter wave plate is kept in its one arm in order to have cross-polarized beam and a rotating half-wave plate was placed at output of interferometer to get different polarization orientations relative to a given crystal axis of LED sample. The variation of the induced quadratic current for LED with respect to the angle of rotation of the half wave plate corresponding to maximum, minimum and pedestal values of cross-polarized autocorrelation (CP-AC) signal is shown in Fig.L.14.1b. Corresponding to this variation, the CP-AC signals with maximum and minimum fringe visibility are also depicted in upper and lower traces of Fig.L.14.2.

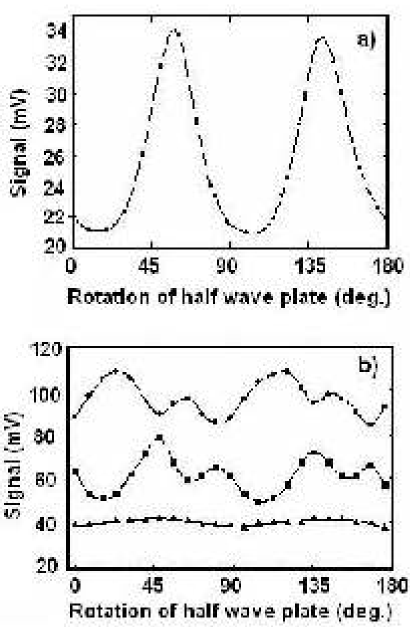

Fig.L.14.1: Typical variation of quadratic photocurrent (a: upper) and variation of maxima, minima and pedestal of CP-AC signals (b: lower) recorded using 200 fs laser pulses from cw mode-locked laser oscillator.

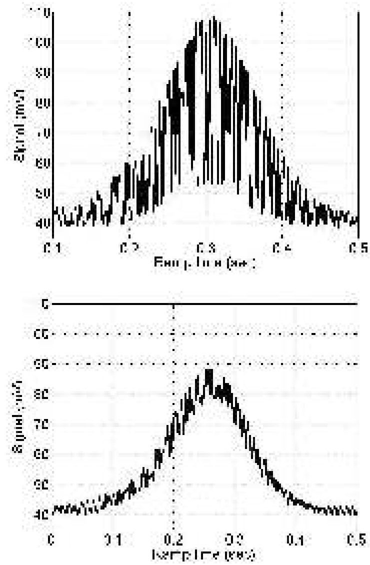

Fig.L.14.2 : Upper and lower traces depict CP-AC signals with maximum and minimum fringe visibility respectively.

A theoretical model has also been developed for CP-AC signals for given polarization relative to crystal axis of the sample. This model accounts for variation of CP-AC signals obtained in case of pure TPA or pure SHG case. By comparing the theoretical and experimentally recorded variation of CP-AC signals, one can estimate the relative contributions of third order non-linearity responsible for TPA and second order non-linearity governing SHG in a given sample, which is otherwise very difficult in case of commercial semiconductor photo devices. [For more details, see **:** A. K. Sharma**,** P**.** A**.** Naik, and P**.** D**.** Gupta, *Applied Physics B (Laser & Optics) 88, 67, 2007*]

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L.15 : Long distance optical guiding of colloidal particles inside the focal region of a holographic axilens

Optical guiding uses the radial gradient force to localize a particle to the beam axis and the radiation pressure or scattering force of the beam to propel the particle along the axis of the beam. For a tightly focussed Gaussian laser beam required to ensure localization of particles on the beam axis, the guiding distance is ~ Rayleigh range and hence quite short. The use of non-diffracting Bessel beam or the extended focal depth achieved by focussing a super continuum beam, have therefore been used to extend the guiding distance. However, in both these approaches, the enhancement in the guiding distance comes at a price. For Bessel beam, the energy is distributed in several rings and therefore there is