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Investigation of the Nonlinear Optical Response of 3-(Dimethylamino)-7-Aminophenothiazin-5-Ium Chloride Dye

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Abstract : The nonlinear optical properties of 3-(Dimethylamino)-7-aminophenothiazin-5-ium chloride dye in the solvent chloroform was studied by Diffraction ring technique using cw diode laser at 532 nm. The obtained results for the nonlinear refractive index, n_2 , and the thermo-optic coefficients , dn/dT , are found to be of the order of $10^{-7} cm^2 / W$ and $10^{-5} k^{-1}$ respectively. To solidate the present experimental results the diffraction ring patterns are reproduced theoretically based on a well known simple model. The rings number of each pattern variation with power agree well with the experimental findings. These results indicate that the azo dye is a promising candidate for applications in nonlinear optical devices.
Keywords: Nonlinear refractive index, Thermo-optic coefficients, Diffraction ring

I. INTRODUCTION

Materials with high third- order nonlinear refractive index are always of large interests for their potential applications on many nonlinear optical devices such as optical limiting, beam flattening, optical switching, weak absorption measurement, spatial dark solution transmission [1-4] and so on.

Changes in refractive index by optical field give rise to a variety of nonlinear phenomena in photoresponsive materials. In the spatial domain, the interplay between divergence of the propagating beam and the nonlinear optical response of the medium can elicit a diverse rang of self-action behaviour such as optical self-trapping, solution formation and spontaneous pattern formation due to modulation instability [5]. A related phenomenon is the spatial self modulation of a coherent beam, which generates a nested array of concentric intensity ring in the far field. Such diffraction ring have been observed in media with thermally-dependent refractive index change[6-9] atomic vapours [10-13], nematic liquid crystals [14-16] ,Kerr media [17,18] ,chromophore- substituted silica [19] and photorefractive crystals [20].

In the present work we presents experimental evidences of observing diffraction pattern in 3-(Dimethylamino)-7-aminophenothiazin-5-ium chloride dye with the calculation of the refractive index change , Δn, effective nonlinear refractive index ,n_2, and variation of refractive index with temperature ,dn/dT .Using theoretical model based on wave theory we have reproduce the diffraction patterns. The obtained results fit reasonably the experimental one.

II. DIFFRACTION RING TECHNIQUES

We can estimate the induced refractive index change, Δn, and the effective nonlinear refractive index , n_2 , for the preceding data as follows. Because the laser beam used in the experiment has a Gaussian distribution, the relative phase shift , $\Delta\varphi$, suffered by the beam while traversing the sample of thickness, L can be written as [8]:

$$\Delta\varphi = kL\Delta n \tag{1}$$

where $k = 2\pi / \lambda$ is the wave vector in vacuum and λ is the laser beam wavelength.

The relationship between $\Delta\varphi$ and number of rings, N , can be written as [21]:

$$\Delta\varphi = 2\pi N \tag{2}$$

The relationship between the total refractive index , n , and nonlinear part of the refractive index , n_2 , can be written as follows [22]:

$$n = n_0 + \frac{n_2}{2} I$$

$$n = n_0 + \Delta n \tag{3}$$

where n_0 is the background refractive index.

The thermal lens signal is expressed as the relative change in power [23]