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The study of self-diffraction of mercury dithizonate in polymer film

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Abstract

When a CW Gaussian beam transmits through the mercury dithizonate doped PMMA film, self-phase modulation of the laser beam gives rise to self-diffraction rings because the medium possesses a temperature-dependent refractive index. The intensity distribution of the rings is explored experimentally and theoretically.

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Keywords: Mercury dithizonate; Self-phase modulation; Self-diffraction; Kirchhoff diffraction integral; Numerical simulation

1. Introduction

When a Gaussian beam transmits through the nonlinear medium, such as nematic liquid crystal [1,2], organic polymer materials [3–5], the self-diffraction will arises. The phenomena have been explored extensively in the last two decades. Mercury dithizonate has obvious nonlinear optical properties [6]. Its photochromism was discovered in the 1950s [7,8], and its mechanism was studied thoroughly [9,10]. The nonlinear refractive index is one of the fundamental properties of a nonlinear material. The effective nonlinear refractive index n_2 of mercury dithizonate doped PMMA film is in the range from 10^{-10} to $10^{-9}\ m^2\ W^{-1}$ [6]. Comparatively, some other nonlinear optical materials such

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as the poly(phenylacetylene) and poly (p-methoxyphenylacetylene) have $n_2 = 6 \times 10^{-22}$ and $n_2 = 1.1 \times 10^{-21}\ \mathrm{m^2\ W^{-1}}$, respectively [11]; the averaged n_2 values of the crystal LN:Mg and potassium titanyl orthophosphate are 2.0×10^{-19} and $1.2 \times 10^{-19}\ \mathrm{m^2\ W^{-1}}$, respectively [12]; and for eosin in a polymer film, $n_2 = 5.58 \times 10^{-16}\ \mathrm{m^2\ W^{-1}}$ [13]. We can see that the nonlinear optical properties of mercury dithizonate doped PMMA film are significant. Here, we report self-diffraction phenomenon that is mainly induced by thermal effect when CW laser beams of 535 and 633 nm transmit through mercury dithizonate doped PMMA film. The intensity distribution of the self-diffraction rings is studied by the experiment and analyzed by the model of a laser beam transmitting a small phase-modulated aperture. The theoretical simulation of the intensity distribution is obtained by Kirchhoff diffraction integral. The theoretical simulation results are in accordance with the experimental results.

2. Experiment and discussion

2.1. The sample preparation

The chemical structure of mercury dithizonate is shown in Fig. 1. Mercury dithizonate and PMMA are dissolved in chloroform separately, the solution of mercury dithizonate (10^{-4} mol/L) and that of PMMA (5% wt.) are uniformly mixed by stirring them together for an hour, then the solution is spread on a clean glass plate uniformly and dried at room-temperature for 24 h [14], The thickness of the film is about 60 μm, and the concentration of mercury dithizonate in PMMA medium is about 5.89×10^{-3} mol/L.

2.2. Self-diffraction

The experimental setup for observing the self-diffraction rings is shown in Fig. 2. A CW TEM_{00}-mode laser at the wavelength of 535 nm

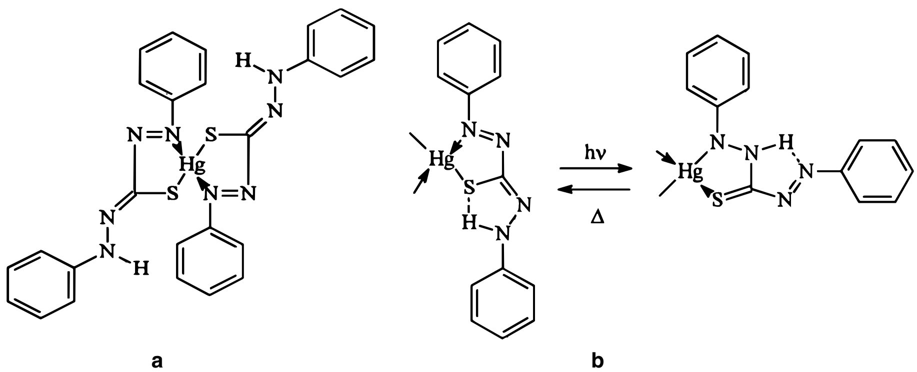

Fig. 1. The chemically structure and isomers of mercury dithizonate.

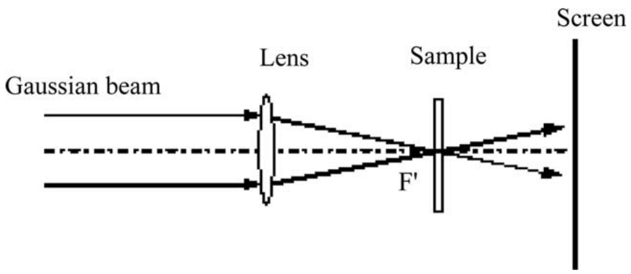

Fig. 2. Self-diffraction experimental setup.