Estimating the nonlinear refractive index of 10W30 oil using visible low power laser beam

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Abstract: Estimating the nonlinear refractive index, n_2, of 10W30 oil using diffraction ring pattern and Z-scan techniques is given. And as high as 1.664 x 10^{-7} cm^2/W value is obtained. Experimental ring patterns are calculated numerically using Fresnel-Kirchhoff diffraction integral where good agreements are obtained.
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Key words: Self-phase modulation, Diffraction ring pattern, Z-scan technique.

1. Introduction

During the past years a large number of materials which exhibit nonlinear behaviors [1-15] i.e., nonlinear refractive index have been found. But the search for new materials has not stopped. The changes in nonlinear refractive index usually described by the equation $n = n_o + n_2 I$ where n_o is the background refractive index which usually measured at low intensities, n_2 is nonlinear refractive index and I is the input light intensity. To evaluate the change in nonlinear refractive index two powerful techniques have been used viz., diffraction ring pattern which was discovered in 1967 by Callen et al. [16] and the Z-scan technique which was discovered by Sheik-Bahae et al. in 1990 [17].

In this article we are presenting the experimental results of estimating the nonlinear refractive index, n_2, by the diffraction ring pattern and the Z-scan of the oil 10W30. Numerical calculations of n_2, are presented too.

2. Experiment

2.1 UV- visible spectroscopic study

Fig. 1 is a photograph of 10W30 oil. The linear absorption spectra of 10W30 oil is shown in Fig. 2. The UV-visible absorption spectra was recorded at room temperature using a (Jenway-England-6800) UV- visible spectrophotometer in the spectral range (375 – 900 nm).

2.2 Diffraction rings technique

The experimental setup comprised a CW a solid state laser (SDL) emitting light at 473 nm and a positive 5 cm focal length glass lens to focus the laser beam at the entrance of the sample cell of thickness 1 mm. A 30 x 30 cm semitransparent screen was used to cast the diffraction ring patterns. The input power was measured using a digital multi-wavelength multi-range meter. The far field diffraction patterns of the laser beam as it pass through the 10W30 oil was recorded using a digital camera. The experimental arrangement is shown in Fig. 3.

Fig. 1 A photograph of the 10W30 oil.

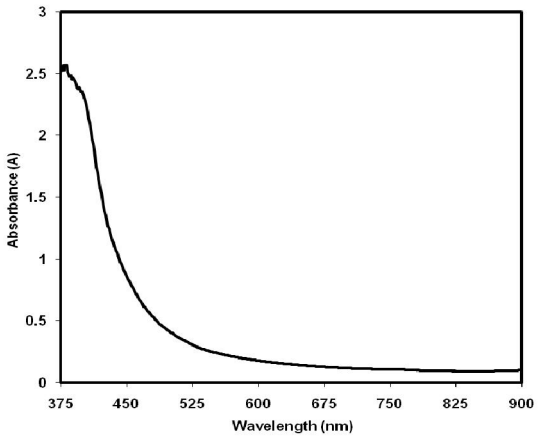

Fig.2. UV-visible absorbance spectrum of 10W30 oil.