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Enhancement of stimulated Raman scattering of CS_2 by using fluorescence of R6G

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Abstract

A new method for enhancing stimulated Raman scattering (SRS) Stokes waves in CS_2 by using Rhodamine 6G fluorescent dye was reported firstly in this paper. The first and second-order Stokes line intensities of CS_2 are measured, respectively, 1.7 and 96.6 times that of pure CS_2. The mechanism of the enhancement together with its potential application is discussed.
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1. Introduction

Stimulated Raman scattering (SRS) is an important nonlinear optical effect for generating tunable coherent radiation in visible, infrared and ultra-violet [1,2]. Comparing with optical parametric oscillation (OPO) and dye laser (DL), SRS has more advantages [3,4]: the Stokes output beam properties of tenability, narrow line-width with high spatial purity and most of all its cost is relatively low. But the low transitional efficiency of SRS has limited its real application. In recent years, scientists would like to find methods to enhance SRS.

A good fluorescent dye medium Rhodamine 6G having a wide fluorescent wavelength region from 540 to 670 nm is commonly used in tunable DL. Due to its wide fluorescent spectral range, a few research works have been carried out in the field of SRS enhancement using this dye. Kwok and Chang [5] reported in the past that fluorescent seeding by dissolving a fluorescent dye in liquid

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droplets could enhance the SRS. But it is difficult to collect the SRS signal output from the droplet cavity because of the weak signal and scattering. Moreover, the magnitude of the micro-droplet and the SRS intensity are both undulations. Zhong et al. [6], Dharmadhikari [7] and Arrivo et al. [8] acquired the enhancement of SRS of using lasing dye dissolved in SRS material and obtained the selective enhancement of SRS. But the problem is that the selection of fluorescent dye and the SRS medium must dissolve each other, and thus limiting its application.

In this paper, we reported a new method to enhance the Stokes waves by using R6G dye. SRS of pure CS_2 was excited by a frequency doubled YAG laser, and the generated SRS light is passed through the R6G fluorescent medium which also pumped by another YAG laser beam. The Stokes waves output from the dye enhancement medium were amplified. A common baseline experimental configuration of the first pump laser in CS_2 and the second pump source in R6G were used for optimal coupling between the Stokes waves and the R6G. A rather large enhancement factor of 1.7 and 96.6 were obtained for the first and the second Stokes line of CS_2, respectively.

2. Experiment and main results

The experimental setup is shown in Fig. 1. A Q-switched frequency doubled Nd:YAG laser with pulse width of 10 ns and pulse energy of 100 mJ, is being used as the SRS pump source. The pump laser was focused at the center of a Raman cell filled with CS_2 to produce the SRS. A portion of the laser beam was split and being used for synchronized power monitoring. First, the SRS of CS_2 was excited by the pump laser.

The Stokes waves with certain Raman frequency shift were emitted from the SRS material. Because the Raman shift for CS_2 in SRS effect is 656 cm^{-1} [9], so the first and the second Stokes wavelength in this experiment are 551.2 and 571.9 nm, respectively. Then, the Stokes waves and the residual pump laser were allowed to continue forward and pass through the fluorescent cell containing R6G dissolved in ethanol after the Raman cell. A powerful fluorescence in the dye medium excited by the residual pump 532 nm laser light was observed. The Stokes lines were enhanced because of the interaction of Stokes lines and fluorescent photons. A grating spectrometer coupled with a CCD optical multi-channel-analyzer was used to collect the spectra both before and after the enhancement. Usually 10 spectra were collected and averaged to improve the signal to noise ratio. The concentration of R6G in ethanol was changed from 8×10^{-6} to 1×10^{-4} mol/L. The measured spectra for different R6G concentrations are shown in Fig. 2. Fig. 2(a) showed the SRS of pure CS_2. The pump laser at 532 nm is recorded as the left most line while the two lines to the right are the first and the second Stokes line, respectively. The higher-order Stokes lines were not detected because of the length of Raman cell is rather short and the pump laser is low. Fig. 2(b)–(d) gives the spectra obtained when the R6G dye cell placed behind the SRS cell was filled with different R6G concentrations. Fig. 2(b)–(d) corresponds to the dye concentrations of 8×10^{-6}, 1×10^{-5} and 1×10^{-4} mol/L, respectively. As observed

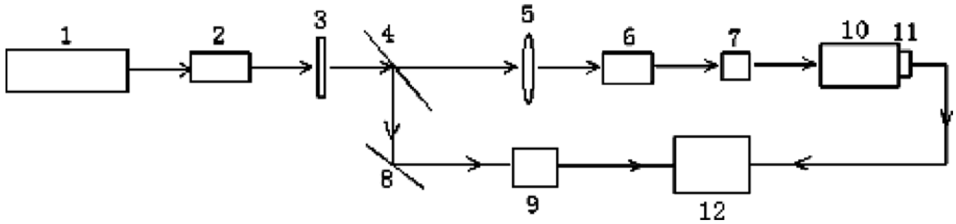

Fig. 1. Schematic diagram of the experimental setup. (1) 1.06 μm Nd: YAG Laser; (2) KDP frequency-doubled crystal; (3) filter (1.06 μm highly reflective and 532 nm antireflective); (4) beam splitter; (5) focusing lens (f = 100 mm); (6) Raman cell of CS_2 (l = 50 mm); (7) fluorescence cell (l = 10 mm); (8) full reflector; (9) photo diode; (10) grating spectrograph; (11) CCD detector; (12) microcomputer.

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