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Study of second harmonic generation by non-linear crystals with phase conjugation

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Abstract

We present the correction of the phase distortion which occurs during the second harmonic generation by non-linear crystals, such as KDP and KTP at high average power laser. This is due to the optical quality and thicknesses of the crystals which in turn influence the quality of the incident laser beam. This phase distortion is corrected by reflecting back the laser beam into the crystal using a phase conjugate mirror. It is found that the conversion efficiency of second harmonic generation without phase conjugation is more than that with phase conjugation. Far field pattern shows that the distortion of the laser beam can be corrected by using the phase conjugate mirror. Fidelity of the beam profile increases significantly with phase conjugation in the case of KDP crystal.

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Keywords: Phase conjugation; Second harmonic generation; Non-linear optics

1. Introduction

Phase conjugation is a well-known phenomenon which can be used for the correction of any wave front distortion. It is useful for high power laser amplifier where wave front is generally distorted due to the thermal effects in the laser material.

Liquid fluorocarbon Fluorinert FC-75 is a biologically safe and chemically inactive material and does not degrade with time under normal laboratory condition. FC-75 is a useful liquid as a phase conjugate mirror because of its high reflectivity as well as fidelity at high energy laser beam [1]. It has a steady state gain coefficient of 4.5–5 cm GW^{-1} and an acoustic decay time of $\tau_{ac} \approx 0.8$ ns. Recently, these kind of liquids are used as SBS media because of their high optical quality. It has been successfully used for other applications, such as pulse compression [2], tunable Brillouin-scattering resonator for distributed feedback laser [3].

In the current study, our aim is to correct the phase distortion which occurs during the second harmonic generation by non-linear crystals like KDP/KTP at very high intensity of laser beam [4]. Idea behind this experiment is that if there is any phase distortion in the laser beam profile while passing through the non-linear crystal, it can be corrected by reflecting back again into the crystal using a phase conjugate mirror. Here, we present the study of second harmonic generation with the phase conjugated beam reflected from a SBS cell filled with liquid FC 75. We have measured the second harmonic conversion efficiency of the non-linear crystals and other beam characteristics like fidelity, near field and far field pattern of the phase conjugated beam.

2. Experiments

Schematic diagram of the experimental set-up used for the second harmonic generation with phase conjugation is

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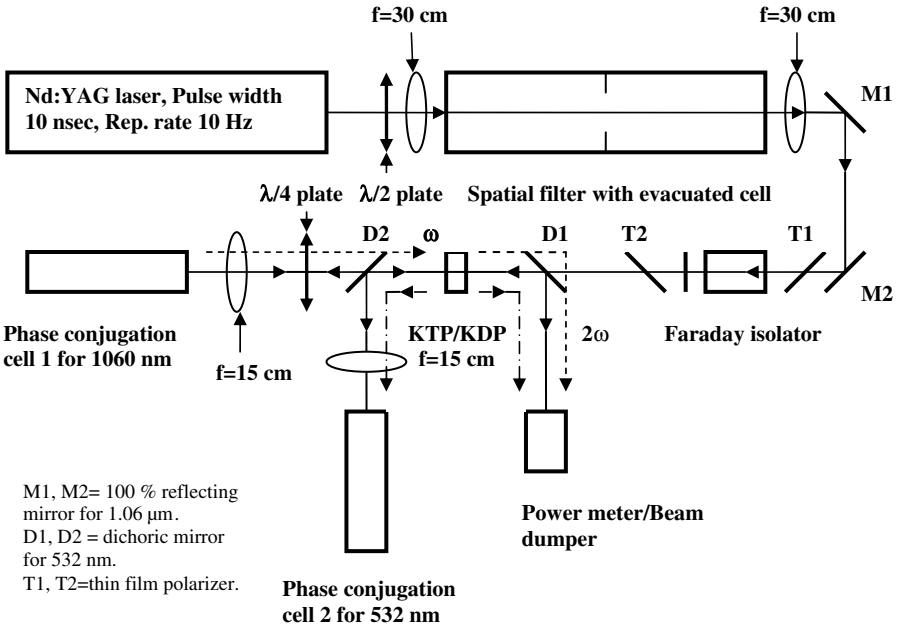
shown in Fig. 1. For this purpose, we have specially fabricated two cells filled with liquid FC-75 to use as phase conjugated mirror. Two ends of these cells are made of glass windows with antireflection coating for 1.06 and 0.532 μm. Details about the preparation procedure of liquid FC-75 is given elsewhere [1]. One of these two cells is used for 1.06 μm (cell 1) and another for 0.532 μm (cell 2). The laser source used here is a linearly polarized, single frequency, TEM_{00} Q-switched Nd:YAG laser which has maximum output energy of 150 mJ. A certain fraction of the incident laser beam at fundamental wavelength passes through the non-linear crystal producing the second harmonic which is reflected by a highly reflecting dichoric mirror (D_2) for 0.532 μm. This beam is then reflected back by the phase conjugated cell 2 in order to compensate any wave front distortion by non-linear crystal. The remaining part of the beam of the fundamental wavelength 1.06 μm is reflected back by the phase conjugated cell 1 and it generates the second harmonic while transmitting back through the non-linear crystal. We do a comparative study of the second harmonic generation with phase conjugated beams reflecting from the cells 1, 2 and the original beam without any phase conjugation. Both the non-linear crystals KDP and KTP used for our experiment were type-II. Thicknesses of the non-linear crystals KTP and KDP were 8 and 30 mm, respectively. Experimental set up which has been used for measuring the far field pattern, near field pattern and fidelity is shown in Fig. 2. The usual method had been used for measuring the fidelity of phase conjugation. Transmission



M1, M2=100 % reflecting mirror for 1.06 μm.
D1, D2= dichoric mirror for 532 nm.
T1, T2= thin film polarizer.

Fig. 1. Schematic diagram of the experimental set-up for second harmonic generation using phase conjugation.

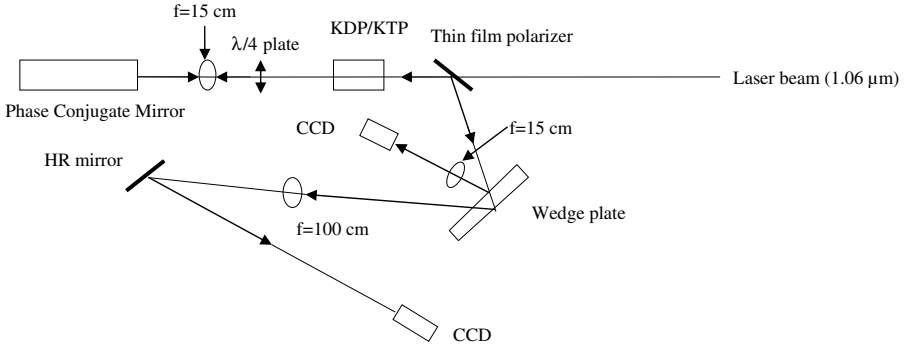


Fig. 2. Experimental set-up for measuring far- and near-field pattern of laser beam.