SELF-FOCUSING OF LIGHT MEDIATED BY CUBIC NONLINEARITIES IN POTASSIUM TITANYL PHOSPHATE (KTP)

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Abstract: We report our observations of the self-narrowing of light beams mediated by dominant dissipative Kerr nonlinearities in a bulk KTP crystal near conditions for second-harmonic generation. Observations agree with comprehensive numerical investigations. Drastic differences between up and down-conversion processes are highlighted.

The impact of competing quadratic and cubic nonlinearities on optical soliton has been extensively studied. In the usual case of second harmonic (SH) generation at or near phase matching between the fundamental frequency (FF) and second-harmonic (SH) interacting waves, the quadratic nonlinearity is dominant in the known materials that are transparent at optical wavelengths, and thus the cubic effects are very small and correspondingly difficult to observe experimentally. We report here observations conducted in a physical setting where the Kerr effect becomes dominant, modifying strongly the well-known beam evolution in media where only quadratic nonlinearities are significant. Two-photon absorption (TPA) was also present, and its effect analyzed numerically.

A suitable configuration for our purposes occurs when the quadratic effects are made small, for example in a crystal with a large Poynting-vector walk-off, or by operating at large wave-vector mismatch between the FF and the SH. Such conditions occur, for example in KTP cut for a Type II *oeo* interaction in the YZ plane. In such esqueme, the walk-off angle between the two, orthogonally-polarized FF waves amounts to a large 1.8º. In addition, the quadratic nonlinear coefficient involved is small, i.e. d_{eff}=1.8 pm/V. These effects combined permit an unambiguous study of the importance of cubic effects in KTP. Notice that because of the huge existing walk-off, the FF(e) diverges rapidly from the FF(o), making quadratic soliton generation, even the "walking" type, impossible at powers below the damage threshold.

The experiments were conducted with input Gaussian beams at 1064 nm from an EKSMA Nd:YAG laser delivering 25 ps pulses. The input beam profile was focused into the input face of the 1 cm KTP bulk crystal cut in the configuration cited above. Figure 1 summarizes the salient points of our experimental observations. When only SH light was present at the entrance facet of the crystal, Fig. 1(a), and also when a weak FF(o) seed was input along with the strong pump SH beam (seeded down-conversion, Fig 1(b)), the FF(o) and the SH output beam waists become narrower as the input pump power increases. Both beams were always observed to feature a clean beam profile. In contrast, the FF(e) exhibited strong deformations due to the large walk-off. The self-narrowing of the SH was observed to be independent of the wave-vector mismatch, a clear indication that the effect is mediated by the presence of dominant cubic nonlinearities.

A very different behavior was observed in up-conversion processes, even at high input peak intensities. The weak SH generated beam was always broke-up. The FF beams always diffract. In addition to the diffraction, the FF(e) beam is displaced at the output from the main propagation axis. A summary of the main features observed in intermediate stages between pure up and down-conversion processes is presented in Fig. 1(c). One concludes that self-focusing induced by cubic nonlinearities only occurs when the strongest beam that propagates inside the crystal is the green light at 532 nm.

To gain further insight into the origin of the observed experimental results, we conducted series of numerical experiments, solving the evolution equations of cw light beams, including nonlinearities, walk-off, TPA, cubic self-phase modulation (SPM) and cross-phase modulation (XPM), and diffraction. A very good qualitative agreement between simulations and experiments was always observed. A comprehensive summary of the numerical results will be presented at the conference.

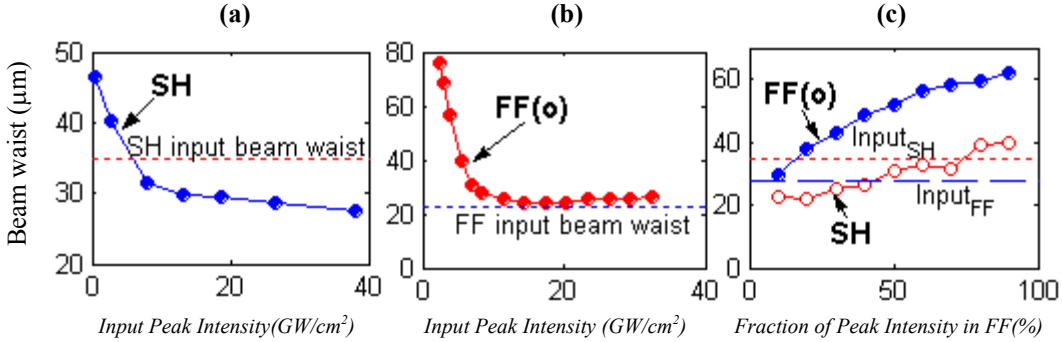

Figure 1: Experiments: Output beam waist of the SH, (a), and the FF(o), (b), versus input power on the SH in a down conversion configuration; (c) Output beam waist versus fraction of power in the input FF(o) for a fixed total input intensity of 33GW/cm^2.

In conclusion, we report our observations of the self-narrowing of the FF(o) and SH beams in down-conversion processes in a bulk crystal of KTP cut for phase-matching in the YZ plane. We attribute the narrowing of the SH beam to the dominant Kerr nonlinearity. The competition between the existing quadratic nonlinearity and the cubic cross-phase modulation effects are responsible for the narrowing of the FF(o) beam. Break-up of the SH was observed in up-conversion schemes, consistent with simulations.

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