High-efficiency multipass optical limiter

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Abstract

We report experimental results obtained with a three-mirror multipass ring optical limiter at nanosecond and picosecond temporal regimes. The enhanced performance is based on accumulative effects, regardless of the nonlinear mechanism employed.

Introduction

The development of passive optical limiters for pulsed laser light has received considerable attention in the past few years. They protect sensors against high intensity light because their transmittance decrease as the light intensity increases. The limiting action efficiency is influenced by three main factors: the nonlinear optical mechanism, the nonlinear material and the device geometry. Many efforts have been directed to enhance the performance of optical limiting devices and the search for new materials presenting high and fast nonlinear optical responses became a lively research area. In addition to materials and the specific nonlinear optical mechanism the study of different device geometries is also important. Several configurations have already been used in optical limiters, going from a simple pair of lenses with the nonlinear material placed in the focus of the first one [1], to more elaborated designs such as the tandem geometry [2], the cascaded focus setup [3], and the limiter based on the total internal reflection (TIR) [4]. The present work reports on experimental results obtained with a highly efficient multipass optical limiter that takes advantage of accumulative processes. The experiments were carried out in two temporal regimes (nanosecond and picosecond) for three different materials: the carbon black suspension in CS_2, difurfuryl ether solution, and Chinese tea, which present as nonlinear mechanism: the nonlinear scattering, reverse saturable absorption and thermal lensing.

Experimental Setup

The experimental setup consists of a three-mirror multipass ring configuration with a layout similar to that reported for Ti:sapphire amplifiers used in ultra short pulse laser systems [5]. It's showed in the figure 1

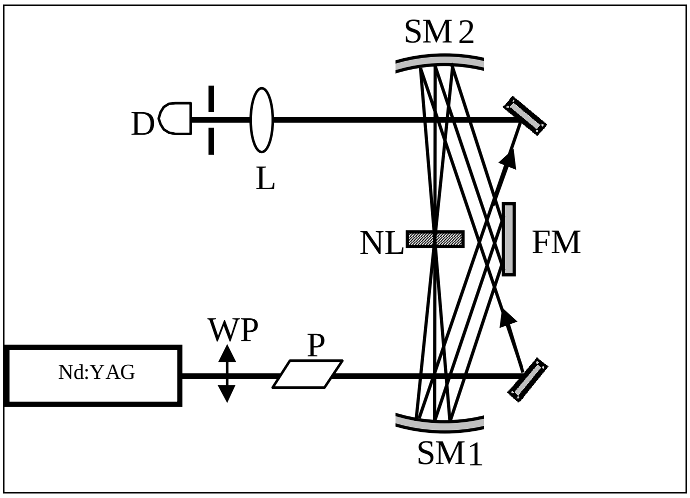

Figure 1 – Multipass optical limiter design

The ring cavity consists of two 1-m radius dielectric-coated spherical mirrors (SM_1 and SM_2), separated by the sum of their focal length, and a 11-cm silver mirror (FM) placed parallel to the line joinig the centers of the curved mirrors at about 12 cm away from it, for experiments in both nanosecond and picosecond regimes. The experiments in nanosecond and picosecond regimes were performed with 10 ns Q-switched and 100 ps Q-switched/modelocked pulses at 532 nm respectively, and with a 5 Hz repetition rate.

Results and Discussions

The feasibility of this limiting device was demonstrated for both nanosecond and picosecond regime. The nanosecond experiment were carried out for carbon black suspension (CBS)m di-furfuryl ether (DFE) and Chinese tea solutions, which present respectively nonlinear scattering, reverse saturable absorption, and thermal lensing. We have used just the nonlinear scattering of CBS in the picosecond time domain. For each sample we performed a n-pass experiment with and without overlapping beams, in a way to keep the same linear transmittance, For overlapping beams, the enhanced performance due to accumulative effects is clear. Figure 2 shows the optical limiting process due a CBS/CS_2 solution, in the nanosecond (a) and picosecond (b) regimes for seven and five passes, respectively.

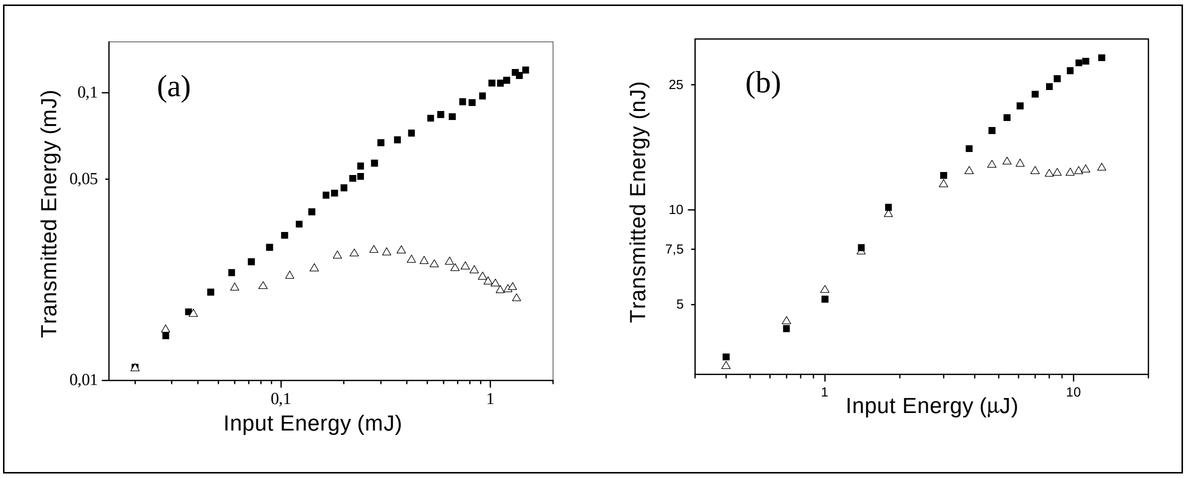

Figure 2 – Transmitted energy versus input energy for a CBS in CS_2: (a) seven passes with nanosecond pulses and (b) Five passes with picosecond pulses. Solid squares are for nonoverlapping beams, while open triangles represent the overlapping configuration.

Conclusions

In summary, we have introduced an optical limiter whose unique design uses a three-mirror multipass ring configuration. The high efficiency relies on the cumulative effect that is achieved when the laser beam is repeatedly focused inside the nonlinear medium. We worked with two different temporal regimes (nanosecond and picosecond) and used media with different limiting action processes, namely, reverse saturable absorption, nonlinear scattering, and thermal lensing.

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