09 PH
A2583.

UNIVERSITY OF ADELAIDE
LIBRARY

Transient Phase Conjugation using Stimulated Brillouin Scattering

by

Shahraam Afshaarvahid

Thesis submitted for the degree of

Doctor of Philosophy

in

The University of Adelaide

Department of Physics and Mathematical Physics

January, 2001

Abstract

It is known that transient effects limit the efficiency of phase conjugation using Stimulated Brillouin Scattering (SBS). Most of the present knowledge of transients in SBS is due to experimental observations, supported by greatly simplified theoretical models which makes the present knowledge of transient SBS incomplete. In this thesis, a one and three dimensional transient model of SBS are developed to investigate the transient regime of SBS and recognize different transient phenomena that affect the performance of SBS. A one dimensional model of transient SBS is initially developed. This model includes the initiation of SBS from noise in a finite cell geometry. Using this model, two transient phenomena are examined carefully; 1) the deterministic threshold oscillations at the beginning of the Stokes pulse and 2) the stochastic intensity fluctuations in the output Stokes pulse. It is shown that the threshold oscillations depend on the phonon lifetime of the SBS material and the immersion length of the laser beam into the SBS cell. It also becomes clear that the pulse compression phenomenon can be understood in terms of the threshold oscillations. The intensity fluctuations in the Stokes pulse, contrary to the threshold oscillations, have stochastic nature. Their occurrence, position in the pulse and their energy content are all random. The effects of the phonon lifetime, immersion length, input energy and pulse duration on these fluctuations are examined. The best parameter space for excellent SBS performance is determined.

Next, the one dimensional model is developed into a three dimensional cylindrically symmetric model. We use a decomposition method to expand the Stokes, pump and sound fields in terms of transverse spatial modes. By introducing block-vectors and matrices, App. B, and using a noniterative method employed by Chu *et al.* [1], we have developed a numerical algorithm that enables us to treat compactly any arbitrary finite number of spatial modes of the Stokes and pump fields. This efficient numerical algorithm could also be useful for the simulation of broad-band SBS, where many temporal modes exist in the input pulse. The model provides an opportunity to study the effects of transient phenomena on the efficiency of phase conjugation (fidelity) by SBS and the mode structure of the Stokes and pump pulse inside the SBS cell. The effect of parameters such as phonon lifetime, input pulse

shape and input energy on the transient fidelity of SBS is investigated. A new transient phenomenon which causes SBS fidelity degradation at high focal intensity (short Rayleigh range) is examined.

Contents