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Currently, one of the major achievements in this project has been in (a) a proposal to use arrays as a way to amplify and shorten pulses, by means of collapse-type mechanisms; in (b) the characterization of three distinct types of nonlinear modes, where that corresponding to the most localized in energy distribution along the array, shows very stable features, including an abscence of mode-mode interaction, which make them excellent candidate of information carriers. Some of these results are to appear in two Optics Letters publications.

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Report of activities for the period October 1, 1990 to September 30, 1993

This is a summary of the activities related to the grant AFOSR-91-0009, "Light beam and pulse propagation in nonlinear dielectrics", for the period October 1, 1992 to September 30, 1993.

I. RESEARCH

The research efforts have been devoted to the two programs described in the proposal with the following results:

Research in the area of pulse propagation in nonlinear waveguides, has been done in collaboration with Dr. Costantino de Angelis, who is currently visiting me for one year. Our research activity, was part of Costantino's PhD program.

We have studied the stability characteristics of pulses propagating in a slab waveguide with a periodic refractive index in the transverse direction. In this case, we consider frequencies which lie in the anomalous dispersion regime, thus the governing equation is the two dimensional nonlinear Schrödinger equation, with a periodic potential. The purpose of this project is to determine if a grating will enable stable pulses to propagate in the waveguide. It is well known that in the absence of the grating, pulses will either disperse as they propagate, or they will collapse in a finite propagation distance (see for example J. Rasmussen and K Rypal, Physica Scripta **33**, 481 (1986)). We have used a variational approach which have been shown to be very effective for this type of problems (M. Desaix et. al., J. Opt. Soc. of Am. B **8**, 2082 (1991); B. Crosignani, et.al., Opt. Comm **89**, 453 (1992); R. A. Sammut and C. Pask, Opt. Lett **16**, 70 (1991)), and the results have then been compared with numerical simulations.

The conclusions of our work, published in [7], are that stable pulses propagate in the waveguide in they are narrow in both the transverse direction and the direction of propagation (narrow here is of the order of the period of the grating) and if the power is below the critical power predicted by the two dimensional nonlinear Schrödinger equation. For any other condition (broad pulses, powers above critical), instabilities always arise. In a report to appear, S. Turitsyn and Yu. Kivshar, have corroborated some of our findings using a different approach.

The second type of waveguide we have been studying in one where the periodic refractive index is along the direction of propagation. Here we have extended the soliton-like solutions to this geometry and we have begun to see how transverse modulational instabilities develop. We also began to numerically study the dynamics of pulses, where the first thing we wanted to determine was if stable pulses exist. Our results indicate this is not the case, instead we typically see pulse break-up that follows an initial tendency to collapse, or broadening when the power is below an estimated critical power. We have now introduced a transverse guiding refractive index profile, to see if a stable regime in achieved. Preliminary studies indicate this is the case.

2) With respect to research on pulse propagation in optical fibers, research began on the dynamics of pulses in an array of optical fibers.

At this time, the first goal here was to find analytically the nonlinear modes in such an array and determine their stability characteristics. These modes correspond to stationary solutions of the governing equations, which are a set of coupled nonlinear schrödinger type of equations. Two regimes are the primary interest: (a) the pulse regime and (b) the continuous wave regime.

As of 9/93, we had already some results in this direction, which were subsequently extended. Currently, one of the major achievements in this project has been in (a): a proposal to use arrays as a way to amplify an shorten pulses, by means of collapse-type mechanisms; in (b): the characterization of three distinct types of nonlinear modes, where

over

that corresponding to the most localized in energy distribution along the array, shows very stable features, including an abscence of mode-mode interaction, which make them excellent candidate of information carriers.

Some of these results are to appear in two Optics Letters publications.

3) I finished our study of the dynamics of pulse propagation in a dense medium of two-level atoms. This is in collaboration with Carlos Lizarraga, a graduate student from the Mathematics Department of the University of Arizona and we have theoretical results that explain the numerical simulations of a recent paper of M. E. Crenshaw, M. Scalora and C. M. Bowden (Phys. Rev. Lett 68, 911 (1992)) on the switching characteristics of such medium, when it forms a thin sample. Our results were published in Optics Letters ([9])

II. CONSULTING

Consulting money was used to pay expenses for Dr. Gregory Luther, who visited me from the University of Arizona. Dr Luther is currently my postdoc, working in problems on nonlinear fiber arrays. Also, Dr. Alexander Rubenchik visited me to talk about the same topic (nonlinear fiber arrays) and he received partial support for his expenses.

III. TRAVEL

Travel *money from this grant* was used *for the following trips:*

1.) SIAM conference of dynamical systems, Salt Lake City, Utah, October 1992, where I gave two talks on research related to this grant.

2.) Visits to Rensselaer Polytechnic Institute and Brown University, August 1993, where I gave seminars on work related to this grant.

3.) Visit to the Arizona Center for Mathematical Sciences, University of Arizona to participate in a Nonlinear Optics Workshop, Sept. 93

IV. PUBLICATIONS

List of publications with AFOSR acknowledgement:

1. Aceves A. B. and Moloney J. V. (1992) "Effect of two-photon absorption on spatial soliton switches", Optics Letters **17**, 1488-1490.
2. Aceves A. B., Moloney J. V. and Newell A. C. (1992) "Spatial soliton optical switches: A soliton-based equivalent particle approach". Invited paper, Optical and Quantum Electronics **24**, 1269-1293.
3. Aceves A. B., De Angelis C., and Wabnitz S. (1992) "Generation of solitons in a nonlinear periodic medium", Optics Letters **17**, 1566-1568.
4. Aceves A. B., De Angelis C. and Wabnitz S. (1992) "Nonlinear dynamics of induced modulational instability in a self-focusing slab waveguide with normal dispersion", Optics Letters **17**, 1758-1760.
5. Aceves A. B. (1993) "Soliton Turbulence In Nonlinear Optical Phenomena". Chapter 11 (pp 199-210) of the book "Nonlinear Waves and Weak Turbulence, with Applications in Oceanography and Condensed Matter Physics", Birkhauser-Boston Eds.
6. Aceves A. B., Wabnitz S. (1993) "Multi soliton-like solutions of wave propagation in periodic nonlinear structures". "Nonlinear Processes in Physics", p. 3. Springer Series in Nonlinear Dynamics, Springer Verlag Eds. (1993).
7. Aceves A. B. and C. De Angelis (1993) "Spatio-temporal pulse dynamics in a periodic nonlinear waveguide", Optics Letters **18**, 110-112.
8. Varatharajah P. and Aceves A. B. (1993) "Light beam propagation in a nonlinear tapered waveguide". Optics Communications **97**, 373-378.
9. Lizarraga C. and Aceves A. B. (1993) "Analysis of switching phenomena in a dense medium of two level atoms", Optics Letters **18**, 687-689.