

ABSTRACT

Title of dissertation: **NONLINEAR PULSE PROPAGATION
THROUGH AN OPTICAL FIBER:
THEORY AND EXPERIMENT**

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Dissertation directed by: **Professor Rajarshi Roy
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Pulse propagation through optical fibers is studied for two different phenomena: (i) the evolution of four-wave-mixing and (ii) the interplay between self- and cross-phase modulation for ultra-short pulses in a polarization maintaining fiber.

For the four-wave-mixing case, we present the results of a study of the dynamical evolution of multiple four-wave-mixing processes in a single-mode optical fiber with spatially and temporally δ -correlated phase noise. A nonlinear Schrödinger equation (NLSE) with stochastic phase fluctuations along the length of the fiber is solved using the Split-Step Fourier method. Good agreement is obtained with previous experimental and computational results based on a truncated-ODE model in which stochasticity was seen to play a key role in determining the nature of the dynamics. The full NLSE allows for simulations with high frequency resolution (60 MHz) and frequency span (16 THz) compared to the truncated ODE model (300 GHz and 2.8 THz, respectively), thus enabling a more detailed comparison with observations. Fluctuations in the refractive index of the fiber core are found to be

a possible source for this phase noise. It is found that index fluctuations as small as 1 part per billion are sufficient to explain observed features of the evolution of the four-wave-mixing sidebands. These measurements and numerical models thus may provide a technique for estimating these refractive index fluctuations which are otherwise difficult to measure.

For the case of self- and cross-phase modulation, the evolution of orthogonal polarizations of asymmetric femtosecond pulses (810 nm) propagating through a birefringent single-mode optical fiber (6.9 cm) is studied both experimentally (using GRENOUILLE) and numerically (using a set of coupled NLSEs). A linear optical spectrogram representation is derived from the electric field of the pulses and juxtaposed with the optical spectrum and optical time-trace. The simulations are in good qualitative agreement with the experiments. Input temporal pulse asymmetry is found to be the dominant cause of output spectral asymmetry. The results indicate that it is possible to modulate short pulses both temporally and spectrally by passage through polarization maintaining optical fibers with specified orientation and length.

NONLINEAR PULSE PROPAGATION THROUGH
AN OPTICAL FIBER : THEORY AND EXPERIMENT

by

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Dissertation submitted to the Faculty of the Graduate School of the
University of Maryland, College Park in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
2004

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2004

Preface

If needed.

Foreword

If needed.

Dedication

If needed.

Acknowledgments

I owe my gratitude to all the people who have made this thesis possible and because of whom my graduate experience has been one that I will cherish forever.

First and foremost I'd like to thank my advisor, Professor Rajarshi Roy for giving me an invaluable opportunity to work on challenging and extremely interesting projects over the past four years. He has always made himself available for help and advice and there has never been an occasion when I've knocked on his door and he hasn't given me time. It has been a pleasure to work with and learn from such an extraordinary individual.

I would also like to thank my co-advisor, Dr. Parvez Guzdar. Without his extraordinary theoretical ideas and computational expertise, this thesis would have been a distant dream. Thanks are due to Professor Robert Gammon, Professor Edward Ott and Professor Thomas Antonsen for agreeing to serve on my thesis committee and for sparing their invaluable time reviewing the manuscript.

My colleagues at the nonlinear optics laboratory have enriched my graduate life in many ways and deserve a special mention. David DeShazer helped me start-off by rewriting the basic simulation code in a user-friendly format. Christian Silva provided help by setting up the GRENOUILLE apparatus and performing some of the simulations. My interaction with Rohit Tripathi, Ryan McAllister, Vasily Dronov, Min-Young Kim, Elizabeth Rogers, William Ray, Jordi Garcia Ojalvo, Riccardo Meucci, Atsushi Uchida, and Fabian Rogister has been very fruitful. I'd also like to thank Wing-Shun Lam and Benjamin Zeff for providing the LaTeX style files

for writing this thesis.

I would also like to acknowledge help and support from some of the staff members. Donald Martin's technical help is highly appreciated, as is the computer hardware support from Edward Condon, LaTeX and software help from Dorothea Brosius and purchasing help from Nancy Boone.

I owe my deepest thanks to my family - my mother and father who have always stood by me and guided me through my career, and have pulled me through against impossible odds at times. Words cannot express the gratitude I owe them. I would also like to thank Dr. Mohan Advani, Dr. Vasudeo Paralikar and Dr. Vinod Chaugule who are like family members to me.

My housemates at my place of residence have been a crucial factor in my finishing smoothly. I'd like to express my gratitude to Sivasankar Pandeti, Jayakumar Patil, Amit Trehan and Punyaslok Purakayastha for their friendship and support.

I would like to acknowledge financial support from the Office of Naval Research (ONR), Physics, for all the projects discussed herein.

It is impossible to remember all, and I apologize to those I've inadvertently left out.

Lastly, thank you all and thank God!

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α alpha
 β beta

IREAP Institute for Research in Electronics and Applied Physics
NSA National Security Agency

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