DEVELOPMENTS IN PHOTOREFRACTIVE TWO-BEAM COUPLING SYSTEMS

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A thesis submitted to the

Faculty of the Graduate School of the

University of Colorado in partial fulfillment

of the requirements for the degree of

Doctor of Philosophy

Department of Electrical & Computer Engineering

2000

This thesis entitled:
Developments in Photorefractive Two-Beam Coupling Systems
written by Valéria B. Damião
has been approved for the
Department of Electrical & Computer Enginneering

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Date

The final copy of this thesis has been examined by the signatories, and we find that both the content and the form meet acceptable presentation standards fo scholarly work in the above mentioned discipline.

Damião, Valéria B. (Ph.D. Electrical Engineering)

Developments in Photorefractive Two-Beam Coupling Systems.

Thesis directed by Dr. Dana Z. Anderson

Photorefractive systems hold the promise for improving the performance of photonic signal processing applications. This thesis describes several developments pertaining to such systems, in particular to those employing two-beam coupling.

The utility of photorefractive systems is stymied by the lack of a component-oriented technology. Conventionally, an entire optical table, full of mirror mounts and other optical components, is required to build a photorefractive system. To address this shortfall, two-beam coupling modules were designed and fabricated, whose ports were standard multimode fiber optic connectors instead of free-space propagating beams, dispensing with the need for time-consuming alignment and adjustments. These modules employ lenses to couple light into and out of our chosen photorefractive medium, crystalline barium titanate. We demonstrate the utility of the modular concept by implementing an autotuning filter constructed solely by these modules.

For even greater integration of the two-beam coupling units, we present a novel spherical crystal geometry which incorporates the functions of both the lenses and of the photorefractive medium in a single element. While investigating these spherical crystals, we observed internal whispering-gallery mode oscillations. These oscillating patterns adopted simple polygonal shapes depending on the pump entry and crystal-axis angles. We modeled the occurrence conditions of the lowest order

triangle pattern by assuming a single two-beam coupling interaction, using standard plane-wave theory.

Also, as part of a higher-level photonic system, we required a carrier suppressor to remove unwanted correlation between different signal-containing beams. By use of two-beam coupling in the novelty-filter configuration, we obtained more than 70 dB of carrier suppression, to our knowledge, the highest reported in the literature. The use of a simplified, geometrical interpretation of an operator theory for two-beam coupling, which provided the proper choice of parameters needed for perfect suppression, was crucial in obtaining this result.

Finally, the full formalism of the operator theory for two-beam coupling is introduced. This formalism provides the freedom of representing the information to best suit the information-processing problem at hand. A closed-form solution for complex coupling is presented for the case of a single spatial mode interaction, the "2-by-2" case. The already reported solutions for pure-real coupling, corresponding to energy transfer only, and that for pure-imaginary coupling, phase transfer only, are given as special cases of the 2-by-2 complex coupling solution.

A meus queridos pais, pela constante e incansável dedicação.

ACKNOWLEDGMENTS

I gratefully acknowledge the following:

First, Prof. Dana Anderson, for the opportunity to work on a well equipped laboratory and for the financial support (with the exception of the last semester) without which this Ph.D. would not have been possible. I am grateful for the most salient, eye-opening, of his teachings: the essentiality of socio-political and communication skills for a successful career.

Most of all, Bruce Tiemann, my partner and unofficial experimental advisor, for his dedication in teaching me the workings of nature in so many different aspects and for helping me develop a set of laboratory skills of fundamental importance on the work developed in this thesis.

Specially, Vladimir Schkunov and Ben Thompson, for their patience in elucidating numerous theoretical questions, and Prof. Kelvin Wagner for kindly listening and providing academic counseling.

Finally, all colleagues who participated in one way or another in my learning experience. In particular, Leslie Czaia, for preparing several of the crystals used in our experiments, for patiently sharing her talents in crystal processing techniques, and for guiding us through the hidden nooks of our laboratories.

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