

**DEVELOPMENTS IN PHOTOREFRACTIVE
TWO-BEAM COUPLING SYSTEMS**

by

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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.

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