A key issue for high power lasers in general and for high-power OPOs is that the intense laser light tends to heat the gain medium (i.e., the crystal) as some of the light is absorbed. We therefore developed a numerical model to simulate thermal effects in optical parametric oscillators. First, we implemented a wavelength conversion code using radially-symmetric Hankel transforms to speed up the simulations. Many comparisons of different Hankel and fast Hankel transform forms were done to determine which would be the best one to use. Once this was working we then added thermal effects. Because of the tremendously disparate timescales an algorithm was developed to accelerate the numerical simulation of the thermal evolution. The results of these studies also allowed several potential improvements to this acceleration algorithm to be identified. Note that without specific algorithms to speed up the simulations, numerical run times would be prohibitive.
Modeling and Control of Agile-Wavelength Laser Sources
AFOSR FY99 Grant F49620-99-1-0016

Final Technical Report
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OBJECTIVES

Air Force flight missions expose pilots and aircraft to attack by guided missiles, and the
development of countermeasures that decrease the risk associated with these threats is
therefore a central issue. Guidance systems for anti-aircraft weaponry are often based
on infrared sensing technology. To jam such systems, a key enabling component for
countermeasures technologies is a high power, tunable laser system that can be
packaged to work robustly on an aircraft.

In the following report we describe work done at Northwestern by and under the
guidance of William Kath and Greg Luther to support modeling efforts of tunable lasers
at Wright Patterson Air Force Base. Several trips to Wright Labs were made to discuss
ongoing projects and support needs with the research group headed by Dr. Ken
Schepler and collaborative work performed at the University of Dayton under the
direction of Prof. Peter Powers. It was found through these visits that key issues were
numerical and analytical modeling of optical parametric oscillators (OPO) that use
quadratic crystals with periodic polling to quasi-phase-match conversion of the pump
lasers. In particular, important issues were the speed and efficiency of numerical
algorithms, and the modeling of transverse, thermal, and photorefractive effects.

ACCOMPLISHMENTS/NEW FINDINGS

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laser light tends to heat the gain medium (i.e. the crystal) as some of the light is
absorbed. We therefore developed a numerical model to simulate thermal effects in
optical parametric oscillators. First, we implemented a wavelength conversion code
using radially symmetric Hankel transforms to speed up the simulations. Many
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to accelerate the numerical simulation of the thermal evolution. The results of these
studies also allowed several potential improvements to this acceleration algorithm to be
identified. Note that without specific algorithms to speed up the simulations, numerical
run times would be prohibitive.
OTHER EFFORTS

Cascaded Optical Parametric Oscillators

In earlier work at Wright Labs and at Phillips Lab a cascaded OPO was developed. This system had two crystals in the laser cavity. The pump laser is converted in the first crystal and the products are then further converted in the second crystal. The hope here is to generate laser light at wavelengths that are typically not obtainable using standard materials with a single stage of conversion. The second crystal complicates the design, so at the suggestion of scientists at Wright Labs and the University of Dayton we considered systems that would accomplish the same five-wave interaction in a single crystal.

Importance Sampling for Polarization Effects in Optical Fibers

We developed a new method to simulate rare events due to random polarization effects in optical fibers. The method allows low probability events to be simulated much more efficiently than with traditional methods.

PERSONNEL SUPPORTED

* Faculty

William L. Kath, Northwestern University
Gregory G. Luther, Northwestern University and Corning Incorporated

* Post-Docs

Dr. Gino Biondini

* Graduate Students

Mr. Sandeep Bhatt
Mr. Richard Moore

* Other (please list role)

PUBLICATIONS

* Journals


* Conferences

Refereed:


Unrefereed:


* Theses


* ACCEPTED

* Journals


INTERACTIONS/TRANSITIONS
* Participation/Presentations At Meetings, Conferences, Seminars, Etc

1. R. O. Moore, G. Biondini and W. L. Kath, Thermal effects and modal competition in continuous-wave optical parametric oscillators, Optical Society of America 2001 Annual Meeting.
2. W. L. Kath, Modeling of quasi-phase-matched optical wavelength conversion, 
Workshop on Nonlinear Optics, Arizona Center for Mathematical Sciences, University of 

3. G. G. Luther, "Controlling resonant wave interactions to enhance frequency 
conversion in nonlinear optics," Fifth SIAM Conference on Applications of Dynamical 

4. G. G. Luther, "Geometry and Control of Resonant Wave Interactions in Nonlinear 
Optical Systems," Michigan Interdisciplinary Mathematics Meeting II, Optimization, 
Algorithms and Control, Department of Mathematics, University of Michigan, Ann Arbor, 
Michigan, May 6 - 8, 1999.

5. G. G. Luther, "Understanding control strategies for resonant waves interactions using 
geometric techniques," Interdisciplinary Seminar in Nonlinear Science, Northwestern 

6. G. G. Luther, "Understanding control strategies for nonlinear waves using geometric 
and spectral techniques," Photonic Modeling and Process Engineering Department, 

7. G. G. Luther, "Geometry and control of resonant wave interactions to improve the 
nonlinear response of optical materials," Department of Mathematics and Statistics and 
Center for Advanced Studies, Topics in Stability Theory Seminar, University of New 
Mexico, March 10, 1999.

8. G. G. Luther, "Geometry and control of parametric interactions: generalization of the 
Poincare sphere," Annual Meeting of the Optical Society of America, Baltimore 
Convention Center, Baltimore, Maryland, October 4 - 9, 1998.

9. G. G. Luther, "Geometry of large nonlinear phase shifts for engineered second-order 
nonlinear-optical processes," Annual Meeting of the Optical Society of America, 
Baltimore Convention Center, Baltimore, Maryland, October 4 - 9, 1998.

NEW DISCOVERIES, INVENTIONS, OR PATENT DISCLOSURES

HONORS/AWARDS