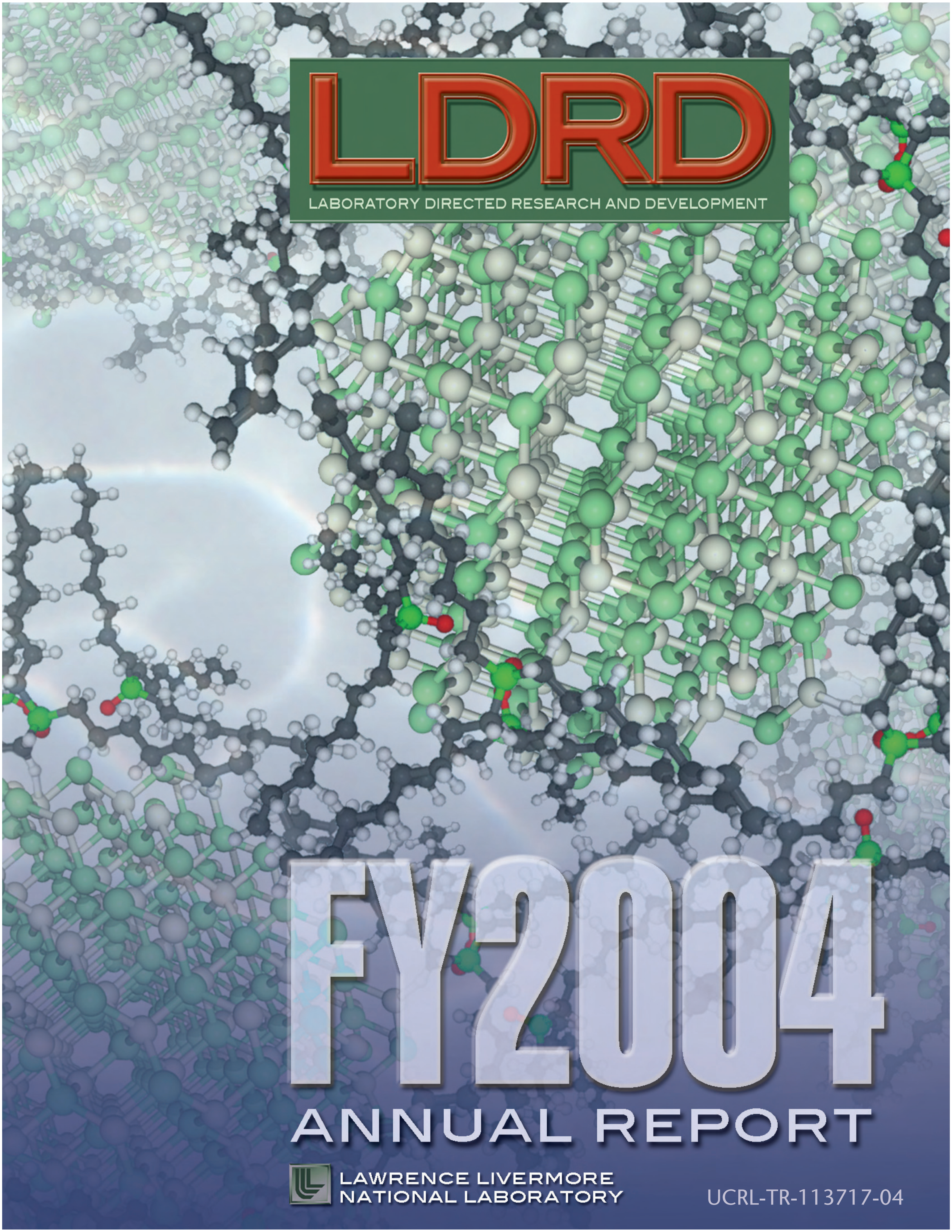

LDRD

LABORATORY DIRECTED RESEARCH AND DEVELOPMENT

FY2004

ANNUAL REPORT

LAWRENCE LIVERMORE
NATIONAL LABORATORY

UCRL-TR-113717-04

Acknowledgments

This *Annual Report* provides an overview of the FY2004 Laboratory Directed Research and Development (LDRD) Program at Lawrence Livermore National Laboratory (LLNL) and presents a summary of the results achieved by each LDRD project. At LLNL, Laboratory Director Michael Anastasio and Deputy Director for Science and Technology Cherry Murray are responsible for the LDRD Program and delegate responsibility for the operation of the Program to the Associate Deputy Director for Science and Technology and the Director of the Laboratory Science and Technology Office (LSTO), Rokaya Al-Ayat. The LDRD Program at LLNL is in compliance with Department of Energy (DOE) Order 413.2 and other relevant DOE orders and guidelines.

The LDRD Program extends its sincere appreciation to the principal investigators of the FY2004 projects for providing the content of the *Annual Report* and to the publications team. The Program also thanks the following members of the LSTO team for their many contributions to this publication: Mary Callesen, administrator; Nancy Campos, database manager; Andrew Hurst, computer specialist; and Cathleen Sayre, resource manager.

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Disclaimer

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Contents

produce a modulated optical carrier at 1550 nm. Arrays of microlenses and fiber optic components will be investigated for spatial imaging applications, including demonstrating a low channel-count system and developing a complete ultrafast imaging system plan.

Mission Relevance

Our goal is to ensure delivery of the next-generation diagnostics needed for stockpile-stewardship experiments at current and future large laser systems. These diagnostics will enable HEDP and ICF experiments, including measuring reaction history, dynamic holhraum temperature, dynamic opacity, and detecting subpicosecond backscatter bursts.

FY04 Accomplishments and Results

A preliminary temporal imaging system design was completed using an older modeling code. We then developed more-detailed models of the system using the codes LinkSim and MATLAB to incorporate all possible physics effects in this system. We also designed and assembled the time lens pump laser and pump dispersion system, which produces the chirped optical pulse in the nonlinear crystal. We completed the design and construction of a precision dispersion measurement system, which will enable proper focusing of the temporal imaging system, as well as the characterization and correction of possible distortions due to higher order dispersive aberrations.

Proposed Work for FY05

We will (1) finish construction of the input dispersion and the measurement and correction of higher-order phase terms in the input and pump dispersive delay lines, which are the primary aberrations that affect the systems impulse response; (2) design and implement high-energy-laser-compatible timing and triggering systems; (3) design and construct the nonlinear crystal sum-frequency-generation device; and (4) complete measurements that will allow us to predict the final system's impulse response shape, the system's temporal field of view, signal up-conversion efficiency, any added timing jitter, and the dynamic range of the temporal imaging system. These measurements will allow us to compare theoretical and experimentally determined maximum allowed output dispersion loss.

Resolution Boosting for Wide-Field and Compact Snapshot Spectrographs

David J. Erskine 04-ERD-067

Abstract

This project develops a technique for boosting the spectral resolution and stability of any existing grating spectrograph by a factor of 5 to 10, by combining it with a small interferometer and processing the data with a custom algorithm. The interferometer creates a periodic grid overlaying the input spectrum, which causes moiré patterns that depend on the narrow spectral features. The moiré patterns are recorded for several interferometer delay values. The patterns are processed to reconstruct the narrow spectral features that

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originally produced them, but which are normally unresolvable without the interferometer. Hence the resolution of the grating spectrograph is increased. This same algorithm and moiré principle can be used to boost the time resolution of streak camera recordings.

The goal is to demonstrate a low cost technique for boosting the resolution performance of existing optical grating spectrographs by 5 to 10×, and increasing the low-light signal-to-noise ratio of Fourier transform spectrometers by 10 to 100×. This performance boost can be exchanged for a much wider field of view, or a much more compact, low-cost, and lightweight spectrograph for a given resolution, thereby dramatically reducing the cost of airborne or spaceborne spectrographs for reconnaissance, aerospace, or planetary exploration applications. Single-shot spectral data (such as from shockwave experiments) can be recorded at wider field of view. The algorithms developed here can boost time resolution for streak cameras in shock experiments using an analogous moiré principle.

Mission Relevance

The spectroscopic techniques developed in this project will offer improved diagnostics for fusion-class lasers and gas gun experiments in support of LLNL's stockpile stewardship mission, and improve the resolution and reduce the cost of spectrographs for remote sensing, in support of LLNL's missions in nonproliferation, advanced military applications, and breakthroughs in basic science.

FY04 Accomplishments and Results

In FY04, we demonstrated a factor-of-6 spectral resolution boosting, from a native 25,000 to final 140,000, by adding a small interferometer to a commercial 0.6-m-long spectrograph. We measured the iodine spectrum, which has many narrow spectral features. Repeating the experiment with a 2× wider input slit would produce a 12× resolution boost (12,500 boosted to 140,000). Achieving 140,000 in a portable tabletop instrument is remarkable when compared to the 50,000-resolution Lick Observatory spectrograph, which is 7-m long and weighs many tons. We demonstrated that multiple spectral moiré data can be combined to form a composite spectrum having almost unlimited spectral resolution.

Publications

Erskine, D. J. and J. Edelstein. (2004). "Interferometric resolution boosting for spectrographs." *Proc. SPIE Conf. on Astron. Instrumentation*, Glasgow UK, June 21, 2004. UCRL-PROC-204704.

Erskine, D. J. and J. Edelstein. (2004). *Multiple-delay externally dispersed interferometry*. Presented at the OSA Conf. on Fourier Transform Spectroscopy, Alexandria, VA, Jan. 31, 2005. UCRL-PROC-206872.