CREOL Welcomes Zel'dovich and Jenssen

CREOL is pleased to announce that two outstanding scientists have joined CREOL in the past months: Dr. Boris Zel'dovich, who has joined us from Chelyabinsk, Russia, and Dr. Hans Jenssen who has joined us from MIT. Dr. Zel'dovich is an internationally known theorist who, along with colleagues at Lebedev Physics Institute (LPI) in Moscow, discovered optical phase conjugation. He will enormously strengthen CREOL's capability in theory of new optical and laser processes. Dr. Zel'dovich has immigrated to the U.S. with his wife, Dr. Nadeya Baranova Zel'dovich, and two children, Nikolay and Varvara. Dr. Zel'dovich has an appointment as a Professor in the Physics Department. Dr. Hans Jenssen is an internationally known crystal grower, having developed growth techniques for and a physics-based understanding of a number of new laser materials. He will add an outstanding capability to CREOL's already strong reputation in new laser materials.

Boris Ya. Zel'dovich was born in Moscow. He graduated from the Physics department of Moscow University, USSR, in 1969. He received his Candidate of Science degree (analog of the PhD) in 1969 from the Institute for Theoretical and Experimental Physics for the theory of relaxation of a quantum oscillator. His subsequent work in the LPI from 1969 to 1981 involved the theory of stimulated and spontaneous molecular scattering, theoretical electron microscopy, classical electrodynamics and nonlinear optics. With his colleagues from LPI he discovered in 1972 a new phenomenon, “optical phase conjugation.” It allows the distortions introduced into a laser beam by an optically inhomogeneous medium to be "undone" via a process that is essentially the production of a "time-reversed wave." He is the recipient of the USSR State Prize for this work. He also predicted and discovered the giant optical nonlinearity of liquid crystals, which turned out to be 10^9 times stronger than the one for normal media. In 1980, he received his second degree (Doctor of Science in Physics and Mathematics) from LPI, while working as a scientific researcher in the Moscow Laboratory of Nobel Prize winner N.G. Basov. In 1987 he was elected a Member of the USSR (now Russian) Academy of Science. In the same year, he moved from Moscow to Chelyabinsk to start the Nonlinear Optics Laboratory. Working there for seven years, he predicted and observed the optical ping-pong effect as a manifestation of the spin-orbit interaction of a photon, and devised methods for experimental registration of the polar (up/down) asymmetry of an optical field. At CREOL he will be conducting research on wave propagation in multimode optical waveguides and

Continued on page 2
Director's Corner

One of the most important roles of Highlights is to announce the arrival of new CREOL faculty and staff. It is indeed with great pleasure and pride that we announce that Professor Boris Zel'dovich and Dr. Hans Jenssen have joined CREOL. Page 1 of the Highlights summarizes the backgrounds, interests and qualifications of these two scientists, so I will not repeat those details here. Rather, I will just note that both are persons of warm and friendly personalities, as well as being excellent scientists. It is a pleasure to work with them, and I am confident CREOL and the community it serves will benefit greatly by their presence.

I first met Boris in 1986 at a meeting in Naples, Italy. I was impressed then, and I am now, by his depth of understanding of physics. Depth of understanding leads to clarity in explanation, and therefore Boris is an excellent teacher and lecturer, as well as an idea stimulant for the Center. We have started a new activity at CREOL that I call “Lunch time with Boris.” At the end of lunch, Boris presents a short lecture on some interesting optics problem. These short discussions remind me that the real reason to be interested in science is that it is interesting and fun.

One of the other roles of Highlights is to announce the loss of faculty. To that end, it is with great sadness that I report the death of Professor Karl H. Guenther, a friend and a colleague. Professor Guenther died peacefully in the early morning of November 4, 1994, at his home in Winter Springs, Florida, following a brief illness. He is survived by his wife Brigitte and daughters Johanna and Julia, 10 and 13 years old, respectively. The sense of loss to his family, friends and colleagues is heightened by the fact that he was only 47 years old, and he had been a model of energy and enthusiasm.

Karl was a Fellow of the SPIE and OSA, and served these societies and the optics community in many ways. He was one of the first faculty hired by CREOL, and thus he played a major role in the development of the Center. His many contributions included chairing CREOL’s Industrial Affiliates Committee, and the science he developed in winning the Florida Governor’s Award for Outstanding Contribution to Science and Technology in 1989. He had a special devotion and loyalty to his students and was revered by them.

Karl’s busy professional life did not allow much leisure time for hobbies. What spare time he did have he spent with his family.

|Zel’dovich & Jenssen (continued) |

irregularly inhomogeneous media, using the methods of nonlinear optics and dynamic holography for the processing of images transmitted through those media. Application to vision in opaque substances, such as live tissue, is the long-term goal of that research.

Hans P. Jenssen received his PhD in Electrical Engineering from M.I.T. with his thesis on “Phonon Assisted Laser Transitions and Energy Transfer in Rare Earth Laser Crystals.” He participated actively in the development of the Crystal Physics Laboratory in the Dept. of EE & CS and the Center for Materials Science and Engineering. Before moving to CREOL, Dr. Jenssen served as the director of M.I.T.’s Laboratory for Advanced Solid State Laser Materials, that replaced the older Crystal Physics Laboratory. As a consultant for several companies he has contributed significantly to several new laser developments such as the tunable alexandrite laser, the Nd:BEL and Nd:YLF lasers and several other new laser materials. At CREOL Dr. Jenssen hopes to continue his research in the electro-optics field and is excited about joining the dynamic environment that exists here.

Perhaps my most enduring image of Karl is that of his lovely young daughters fretting over him. A colleague, a friend, a husband, a father—he will be greatly missed by many.

Friends and colleagues wishing to remember Karl may do so by contributing to: The Professor Karl Guenther Education Fund, c/o CREOL. This fund has been established for the education of Professor Guenther’s children.

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Technologies Available for Transfer

CREOL faculty and students have developed several technologies which are suitable for conversion into products by industry. A brief description of them is given below, followed by the name of a faculty member who could discuss the technology with a company which might be interested in commercializing it. While CREOL faculty can describe the technology, it is the responsibility of UCF's Division of Sponsored Research and Training (Mr. Michael Herforth; 407-823-3778) to negotiate the actual terms of transfer.

*Instrument for Measuring Nonlinear Optical Properties of Matter Including the Nonlinear Index of Refraction, n2, and Two-photon Absorption Coefficient. A simple and sensitive laser technique has been developed for measuring nonlinearities of materials called "Z-scan." The method requires a laser, lenses, an adjustable aperture, and a photodetector. By moving the material through the focal region of a lens (Z-scan), the photodetector's output can be interpreted directly to yield the sign and magnitude of both the nonlinear index of refraction and nonlinear absorption coefficient. Variations on this technique allow the wavelength dependence and time development of these non-linearities to be determined. (Dr. David Hagan; 407-658-6817 or Dr. Eric Van Stryland; 407-658-6814)

*Extended Range Bar Code Scanners for Airport Traffic Control. A system has been devised which would employ extended range, optical bar-code scanners, integrated with appropriate stored data and data processing capabilities, for detecting and reporting the presence and movements of aircraft and vehicles on airport surfaces. Aircraft and vehicles marked with bar-coded information can be identified by such scanners. Unmarked objects can also be detected by optical scanners, and warnings concerning their presence can be generated. When two or more such scanners detect an aircraft or vehicle they can identify it, determine its type and measure its state of motion with unsurpassed accuracy. Analysis of both scanned and stored information enables ground controllers and flight crews to more efficiently and safely manage on-ground traffic at airports. In this manner the system provides an important tool for optimizing the utilization of airports and the safety of the flying public. (Dr. Michael Bass; 407-658-3977)

New Coherent Laser Radar Developed at CREOL

In a coherent laser radar system, the signal-to-noise ratio (SNR) increases linearly with the area of the receiver optics up to the point where the receiver diameter exceeds the size of the speckle, the "isoplanatic patch" size, at the receiver pupil plane. Since this size is only on the order of centimeters (depending on the laser wavelength and the atmospheric conditions), the question naturally arises as to whether there is a way around this limitation on increasing the SNR, something one always strives to do in radar systems.

For the past two years a team of CREOL and ECE faculty, staff, and students has been designing and developing an approach to beat this limit. If two physically separated receivers and apertures, which are pointed at the same target, are each sized to the speckle diameter, then the detected fields will be independent. Thus, while the two IF signals have the same frequency (both receivers use the same local oscillator) but are phase-independent, they will add incoherently and produce no net improvement in the SNR. Albeit the composite IF is greater, the noise will increase by the same amount.

However, if the phase of either IF signal is shifted to match the phase of the other one, or if the phase of each IF is matched to a local reference, then the signals will add coherently and produce a near two-fold increase in the SNR. This can be caused by sensing the phase of each IF and then applying the appropriate compensating optical phase shift to each signal or its corresponding local oscillator.

An electro-optical system has been developed in which the IF phases of each receiver are sensed and compared to a local reference. A control system generates a compensating voltage, which is applied to a piezoelectric cylinder around which is wrapped a single mode fiber that carries the signal photons. The expansion of the piezoelectric cylinder results in stretching the optical fiber, causing the desired optical phase shift of the signal field.

A coherent laser radar system using this approach has been built consisting of a single frequency CW Nd:YAG transmitter, two coherent receivers located adjacent to each other and pointed at the target, and processing electro-optics to compare and correct the phase of each IF, relative to a local reference.

This system has just been tested over a one-kilometer range at BMDO's Innovative Science and Technology Experimentation Facility (ISTEF) at Kennedy Space Center with dramatic results: For the first time, the IFs of two

---Continued on page 4---
CREOL Demonstrates New Mid-IR Laser

As part of an ongoing effort to develop new diode-based laser sources, CREOL researchers under the direction of G.J. (Jeff) Dixon have recently demonstrated a new type of mid-IR laser that is based on intracavity difference frequency mixing. While diode lasers with output wavelengths between 780nm and 1000nm operate efficiently at room temperature, devices with output wavelengths in the 3 to 15 micron range require cryogenic cooling. For this reason, they are poorly suited for applications outside the research laboratory. Difference frequency lasers use a nonlinear optical crystal inside the cavity of a diode-pumped solid-state laser to shift the output of a well-developed, near-IR diode to longer wavelengths. By choosing the wavelength of the solid state laser and the diode appropriately, wavelengths from 3 to beyond 15 microns can be generated at room temperature.

In recent experiments, Edelsey Said, Mike McCann, Peter Wigley and Quan Zhang mixed the output from a broadly-tunable Ti:sapphire laser with the intracavity field of a diode-pumped Nd:YAG laser in AgGaS2. By tuning the Ti:sapphire from 792nm to 857nm, they were able to generate a mid-IR output that was continuously tunable between 3.1 and 4.4 microns. In addition, a 4.2 micron output was also obtained by replacing the Ti:sapphire laser with an 845nm diode laser. The 150mW output power that was observed from the Ti:sapphire-based system, is adequate for most trace gas sensing applications and roughly two orders of magnitude greater than previously-reported values.

Further difference frequency laser development is expected to result in a family of compact, mid-IR sources that can be used for the detection of molecular gases at the part per billion level. Because they will be based on long-lived, near-IR diodes we expect these devices to find numerous applications in environmental monitoring, process control and toxic gas detection.

CREOL Welcomes Visiting Scientists

Sebastien Allard is a student from ENSPM, Domaine University de Saint-Jerome, France, working with Dr. Chai in crystal growth research.

Luca Baraldi, from the Swiss Federal Institute of Technology, Switzerland, is a scientist working with Dr. Stegeman in nonlinear optics.

Also working with Dr. Stegeman in nonlinear optics is Maria Diaz-Garcia, a student on a fellowship from Spain's Universitat Autonoma.

Aristide Dogariu is a visiting scientist from Transylvania University, Romania, and is working with Dr. Boreman on infrared systems.

Kai Gabel is a scientist working with Dr. Martin Richardson on laser plasma research. This help is funded by Germany's Max Planck Institute.

Also assisting Dr. Richardson in laser plasma research are Masataka Kado, a scientist whose work is funded by the Japanese Society for Promotion of Science, and Tadashi Kanabe, a visiting scientist from Osaka University, Japan.

Coherent Laser Radar (continued)

receivers were locked together over a signal dynamic range of 45dB, and could track relative phase shift changes with just 10 percent phase error at 400 Hz, which is comparable to anticipated atmospheric fluctuation rates. This is the first time such a system has been built.

Within the coming six months, a larger system will be built consisting of eight independent coherent receivers with all of the processing electro-optics to coherently combine the eight IFs. Such a system should be relatively immune to turbulence-induced signal fading, the problem which motivated this project.

Finally, it is important to add that this two-aperture coherent receiver system has been used to sense (and record) the amplitude and phase variations that occur due to speckle propagation in a turbulent atmosphere. This 2 km (round trip) data is unique, because for the first time, relative target-to-platform motion effects can be eliminated from the phase data. This is accomplished by subtracting the two phase signals, prior to statistical analysis. This data will also allow study of amplitude and phase cross-correlations. In particular, while the amplitude and phase themselves are anticipated to be uncorrelated, the temporal correlation lengths of each should be correlated. This hypothesis will be verified upon completion of the data analysis.

This work was done with support from the Ballistic Missile Defense Organization's Innovative Science and Technology Directorate, contracted through the Office of Naval Research, and under the guidance of Dr. C.M. Stickley, Principal Investigator. Key contributors to this work have been Dr. Philip Gatt, Research Scientist; Tom Costello, Dean Heimmermann, Diana Castellanos and David Hefely, graduate students; Chie Gagge, undergraduate student; and Dr. Arthur Weeks, Assistant Professor of the ECE Department. Profes. Ron Phillips, Jim Harvey, Harley Myler and Larry Andrews also contributed to this research.

Continued on page 5
CREOL Student News

The following CREOL Graduate Research Assistants have recently achieved educational milestones:

Terri L. Alexander completed her M.S. Degree in EE in May 1994.
M. Sheik-Bahae left to take a faculty position at U. of New Mexico.
Paul Buck passed his PhD candidacy exam in EE in August 1994.
Myoungsik Cha received his PhD in Physics in August 1994.
Nicholas J. Croglio Jr. finished his MS in ECE in August 1994.
Arnold Daniels received his PhD in EE in August 1994.
Jason Eichenholz received a Newport Award for Excellence in Graduate Research, November 1994.
Steven Grantham passed his PhD qualifier exam in EE in September 1994.
Dean Heimmermann received his MS in EE in November 1994.
Jin Kang passed his PhD qualifier exam in EE in April 1994.
Akira Otomo passed his PhD qualifier exam in EE in April 1994.
Lolita Ponnampalam passed her PhD qualifier exam in EE in April 1994.
Wisam Rabadi passed his PhD candidacy exam in EE in November 1994.
Shankar Raneru received his MS degree in EE in August 1994.
Paul Reese received his BSEE in May 1994, and is working in electronics with Graseby Optronics Inc. in the Central Florida Research Park.
Alan Rubin received his MS degree in EE in August 1994.
Michael Sundheimer received his PhD in EE in August 1994.
Carlos Trevino passed his PhD qualifier exam in EE in April 1994.
Heike Voss received her MS degree in EE in May 1994.
Zuo Wang passed his PhD candidacy exam in EE in April 1994.
Haisheng Wang received a PhD in physics in November 1994.
Tiejun Xia received a PhD in physics in November 1994.

Congratulations!

CREOL Faculty Members Edit Revised Handbook of Optics

The Handbook of Optics, Second Edition, has been published by McGraw-Hill and sponsored by the Optical Society of America. CREOL faculty have been instrumental in this, greatly revised and expanded, edition of what has become a classic in the field of Optics. Michael Bass is the Editor-in-Chief of the Handbook and is responsible for the overall contents of the two-volume Handbook. It contains over 80 articles (3400 pages) on almost all of Optics. With the articles grouped into topical areas to make it easier to find related materials, the Handbook will serve for many years to come as a primary reference book for anyone working in Optics. Eric Van Stryland is one of three Associate Editors responsible for modern optics (the others are William Wolfe of the Optical Sciences Center at the University of Arizona responsible for classical optics, and David Williams of the Center for Visual Science at the University of Rochester responsible for vision and imaging).

The following CREOL faculty wrote four of the Handbook’s articles. They are:

Jim Harvey: X-Ray Optics
Glenn Boreman: Modulation Transfer Function Techniques
Bill Silfvast: Lasers
Alan Miller: Optical Interactions in Solids

OSA Students Hold Conference

In keeping with its duty to promote communication in optics, the CREOL student chapter of the Optical Society of America (OSA), in conjunction with its counterpart at Georgia Tech, organized and executed the first inter-center conference.

More than a dozen people from CREOL and an even greater number from Georgia Tech’s optics center participated.

The conference was held in Atlanta, and the travel and lodging expenses were partially defrayed by a student activity grant. The host chapter’s students conducted lab tours, and the students from CREOL presented a number of short technical talks.

Overall, the conference was a terrific success, due to the enthusiasm and interest of the members. Thanks to everyone who took part.
Technology Transfer to Laser Ionics

Laser Ionics, Inc., a small laser company based in the Orlando area, has signed a licensing agreement with UCF and CREOL to manufacture and sell a compact semiconductor laser source capable of generating high-power ultrashort optical pulses. The new laser source, called the MLD 2000, was unveiled at the Conference on Lasers and Electro-Optics (CLEO) in May, at the Anaheim (CA) Convention Center. The laser source, developed by Peter Delfyett, relies on a small semiconductor optical amplifier as a gain element, and incorporates both active and passive modelocking techniques to generate the ultrashort optical pulses. The motivation behind the development of the source was the commercial need for a compact and efficient source capable of generating optical pulses with temporal durations on the order of one-trillionth of a second, with sufficient peak intensities to induce nonlinear optical phenomena in optical waveguide structures. It is anticipated that the laser source will be incorporated into state-of-the-art ultrafast photonic technologies, and has the potential to revolutionize the way laser science is performed.

While ultrafast laser sources have been available since the early 1970s, proposed applications incorporating such sources become unrealistic, owing to the laser's size, inefficiency, excessive operating costs and frequent and costly maintenance. The attributes of the modelocked diode laser, which make it an attractive alternative to currently available ultrafast laser systems, are its portability and small size—typically a few square feet—and the fact that it can operate from a standard 110-volt electrical outlet. Another advantage of the system is its comparatively low cost, anticipated to be offered at an 80-percent cost reduction, compared to a conventional modelocked Ti:Sapphire laser system. The development of the high-power, modelocked laser diode system now moves high-speed photonic technologies and applications one step closer to reality.

Applications for the new system will be found in fields spanning telecommunications, medical imaging, automotive collision avoidance systems, ultrafast spectroscopy, high-speed electronic circuit testing, and high-speed computer processors, to name a few.

In addition to the scientific and technological potential that may be obtained from the commercial availability of the MLD 2000, the University believes this technology transfer effort could provide a competitive edge to local industries and businesses, potentially creating more jobs and strengthening the Central Florida economy.

Development on the system is continuing, with anticipated success in generating shorter and more powerful optical pulses at higher pulse repetition rates and at new wavelengths, with continued packaging efforts to allow the system to even fit in the palm of one's hand.

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**Talks & Papers Presented/Published**

**Papers Published**


K. Al-hemayri, A. Villeneuve, J.U. Kang, G.L. Stegeman, J.S. Atchison and C.N. Ironside, "Ultrastable all-optical switching in AlGaAs Directional Couplers at 1.55 mm without multi-


P.J. Delfyett, A. Dienes, J.P. Heritage, M.Y. Hong & Y.H. Chang, "Femtosecond hybrid modelocked semiconductor lasers and amplifier dynamics" (Invited Paper), Applied Physics B, Special Issue on Ultrafast...
Talks/Papers (continued)


P.J. Delfyett, "Ultrafast semiconductor lasers (Are they ready for the real world?)" (invited paper), IEEE LEOS Newsletter, 8(4), 1-6 (1994).


Papers Presented at Conferences:


G. Boreman, "MTF measurement using spatial noise targets" (invited paper), 9th Meeting on Optical Engineering, Israel, October 1994.


A. Diennes, J. Heritage, M. Hong, Y. Chang, P.J. Delfyett, "Semiconductor laser amplifier dynamics and femtosecond hybrid mode-locked diode lasers" (invited talk), Optical Society of America Annual Meeting, Dallas, TX, October 1994.


Seminars & Presentations Given:


G. Boreman, "MTF measurement using three-bar and four-bar targets" (seminar presented), Ben-Gurion University of the Negev, Beer-Sheva, Israel, October 27, 1994.
## New CREOL Contract and Grant Awards

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<td>IR Scene Projector Design Study</td>
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<td>DOD/Army/Belvoir</td>
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<td>Femtosecond Pulse Generation</td>
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## Status of New CREOL Building

While the new CREOL building on the UCF campus near the Engineering Building is 85-95 percent complete, we do not have a move-in date. We expect it will be in April or perhaps even later. We are excited about the move and are keeping our fingers crossed that our move will not be delayed much longer.