

SPECIAL EXPERIENCES FOR GRADUATE STUDENTS

Graduate students work on almost all the research projects at iQUEST. The projects make it possible for them to work towards their PhD theses. They have written numerous research papers, and have had the opportunity to present their work at domestic and international conferences. They are also involved in mentoring undergraduate students and they participate in summer programs for both undergraduates and high school students.

RESEARCH EXPERIENCES FOR UNDERGRADUATES

Guenter Ahlers

John Royer, (now a graduate student at the University of Chicago) did research on Rayleigh-Benard convection in Dr. Ahler's labs and wrote a Senior Thesis about his results. He also was first author on a paper in Physical Review E:

Wave-number Selection by Target Patterns and Side Walls in Rayleigh-Benard Convection, **J.R. Royer**, P. O'Neill, N. Becker, and G. Ahlers, Phys. Rev. E **70**, 036313 (2004).

Troy Schubert is presently doing experiments on Rayleigh-Benard convection in Dr. Ahlers' labs. Troy will be a Senior next Fall in the College of Creative Studies.

Jeffrey Bode

All of the grants managed by iQUEST involve undergraduate researchers.

The Dreyfus New Faculty Award is award for both Research and Teaching and the involvement of undergraduates researcher is an important component of this funding. This grant has supported Joe Moss for his involvement in the synthesis of dynamic organic molecules.

A major component of the NSF Career Award is the development of a new model for encouraging undergraduates into the study of organic chemistry at the earliest possible stage in their careers. This unique program allows the most motivated and talented undergraduates to begin undergraduate research projects in their sophomore year by getting hands on training in modern organic research in lieu of the usual sophomore organic laboratory class. This program exposes these students to the success and failures of scientific research instead of the cookbook, everything works environment of the traditional lab course that belies the challenges and opportunities of organic chemistry. Numerous students have participated in this program. Evie Rosen continues to work on projects funded by this grant. She will be entering her senior year and already has one major publication from this research.

The subcontract from the Japanese Ministry of Health Sciences is executed largely by undergraduate researchers under the direction of our collaborator, Dr. Yoko Yamakoshi. This project is currently the topic of Michael Drew's projected doctoral thesis; he began this project as an undergraduate researcher. It has supported two other undergraduates on the model described above, Natalie Spritzer and Adam Olinger. Both of these undergraduates made significant contributions to the synthesis of a novel nanoscaffold for modifying the tip of AFM probes.

Dirk Bouwmeester

Five undergraduate students have been working on the projects sponsored by the two NSF grants. The students performed independent literature studies during the Winter and Spring term and performed experimental research in the summer.

Frank Brown

Last summer, an undergraduate, Peter Philips, worked in the group. A publication with him as co-author has recently appeared in press: G. Brannigan, P. F. Philips and F. L. H. Brown, "Flexible lipid bilayers in implicit solvent", Physical Review E, 72, Art. No. 011915 (2005).

David Cannel

An undergraduate from Engineering, Chris Takacs works with Dr. Cannell, and they have just submitted a paper with Chris as an author. He has been an invaluable contributor to the whole NASA project.

Andrew Cleland

Four undergraduates worked in the lab over the reporting period.

Mattanjah DeVries

Three undergraduates participating in research. Two of them plan on returning the coming year, one continued during the summer.

Peter Ford

Two UCSB , three U. Muenster, and two Lake Superior State U, Michigan undergraduates participated in research.

Tom Gerig

One student participated fully in a project to study solvent interactions with a designed peptide. This includes analysis and interpretation of NMR and CD spectral data as well as molecular modeling activities.

Leroy Laverman

Several undergraduates participated in the design and construction of a new instrumentation. They did this through a series of courses offered through the College of Creative Studies. The experiments that students have tested are being implemented in the Chemistry 116CL course this fall.

Bruce Lipshutz

Jeff Zira worked in the group for 2 years. He is now employed at Roche Biosciences in Palo Alto.

Dan Little

Miguel Buenrostro – NSF, PRF, P&G. Continued to do research this summer; will be attending the Masters in Biotechnology Program at San Jose State. Miguel's research efforts were closely guided by Dr. Arup Maiti, a Procter & Gamble postdoctoral researcher in the Little' group.

Jack Graham – NSF, PRF, received the 2005 Pfizer Summer Undergraduate Research Fellowship in Organic Synthesis – see: <http://www.chem.ucsb.edu/pfizer2005.pdf> Jack's research activities were closely guided by Gisele Nishiguchi, a graduate student in the Little group.

Yvette Mimieux – NSF & PRF; last fall, she began her first year of graduate studies in organic chemistry at UC Santa Cruz. Yvette's research efforts were closely guided by Dr. Arup Maiti, a Procter & Gamble postdoctoral researcher in the Little' group.

Alejandro Preciado – NSF & PRF; employed by Biosearch Technologies located in the San Francisco Bay Area. Alejandro's efforts were closely guided by (now Dr.) James Gerken, a graduate student in the Little group.

Daniel Shelton – NSF; is currently attending graduate school, studying organic chemistry, at UC Irvine. Dan's efforts were closely guided by (now Dr.) Jon Parrish who was then a graduate student in the Little group.

Verena Trepohl – PRF & P&G. Verena just completed an ~3 month course of study here; she's from Münster, Germany. Verena performed undergraduate research under the tutelage of Gisele Nishiguchi, one of my advanced graduate students, and made excellent progress. Like the others (see below), it is likely that Verena will co-author her first publication as a result of her efforts in my group at UCSB.

Carolyn Wade – NSF & PRF; will graduate from UCSB in June of 2006. James Miranda supervised Carolyn's efforts. James is currently a graduate student in the Little group.

Four of the undergraduates were coauthors on their very first publications:

Remote Substituent Effects upon the Rearrangements of Housane Cation Radicals, J. B. Gerken, S. C. Wang, **Alejandro B. Preciado**, Y. S. Park, G. Nishiguchi, D. J. Tantillo, and R. D. Little, *J. Org. Chem.*, 70(12), 4598-4608 (2005)

From Dimerization, to Cycloaddition, to Atom Transfer-Cyclization (ATC). The Further Chemistry of TMM Diradicals. A. Maiti, J. B. Gerken, M. R. Masjedizadeh, **Yvette S. Mimieux**, and R. D. Little, *J. Org. Chem.* **2004**, 69(25), 8574-8582 (2004)

Indirect Electroreductive Cyclization and Electrohydrocyclization Using Catalytic Reduced Nickel(II) Salen, J. Miranda, **Carolyn Wade**, and R. D. Little, *J. Org. Chem.* **2005**, 70, accepted.

Titanocene(III)-Promoted Reformatsky Additions, J. D. Parrish, **Daniel R. Shelton**, R. D. Little, *Org. Lett.* **2003**, 5(20), 3615-3617.

CAMP & UCLEADS programs (Miguel Buenrostro; Yvette Mimieux; Alejandro Preciado)

Two of the more significant and important activities for undergraduates, where RDL has taken a leadership role, include the **UC-LEADS** and **CAMP** programs. He has also mentored particularly gifted and highly motivated undergraduates who have elected to participate in the UCSB College of Creative Studies program. The University of California's Leadership Excellence through Advanced Degrees (**UC LEADS**) program is dedicated to the education of California's future leaders by preparing promising students for advanced education in science, mathematics and engineering. The program is designed to identify upper-division undergraduate students with the potential to succeed in these disciplines, but who have experienced situations or conditions that have adversely impacted their advancement in their field of study. The Scholar gains valuable educational experience, the University a better prepared and more diverse graduate applicant pool, and the State, well-educated future leaders. **Yvette Mimieux** and **Alejandro Preciado** are two recent success stories that participated in this program while in Dr. Little's group. Yvette has just begun her studies for the Ph.D. in Chemistry at UC Santa Cruz, while Alejandro is now gainfully employed by Biosearch Technologies located in the San Francisco Bay Area. Both recently became first-time authors, this as a result of their involvement with Dr. Little's NSF sponsored research program. Alejandro also participated in the California Alliance for *Minority Participation* (**CAMP**) program in Science, Engineering and Mathematics. It is supported in part through a cooperative agreement with the National Science Foundation. The primary goal is to significantly increase the number of B.S. degrees granted to underrepresented minority students in science, technology, engineering, and mathematics majors at the University of California. In addition to faculty mentored research experiences, principal activities include peer mentoring and tutoring, collaborative learning, presenting at scientific conferences,

science writing and co-authorship, technology proficiency, and preparation for graduate school. **Miguel Buenostro**, also a participant in the CAMP Program, is continuing his research efforts in Dr. Little's group.

John Perona

Three undergraduates students worked on projects in the lab. These included "Crystalization of tRNA-dependent amidotransferase", "Characterization of mutants in glutaminyl-tRNA synthetase" and "Crystallization of phosphoseryl-tRNA synthetase".

Kevin Plaxco

Three undergraduates in the laboratory (Thomas Dillon, Nicola Cingel and Tony Scopatz) have co-authored papers under IQUEST-supported research that are in print. A third (Mona Danashi), is an author on a paper in press, and two more (Cara Beasley and Michel Fortin) are authors on papers currently in preparation.

Joan-Emma Shea

An undergraduate student has been working on developing computational models to describe chaperonin-mediated protein folding.

Mark Sherwin

James Lee worked on a project called "Time Domain THz Spectroscopy of Photonic Crystals". He is going to graduate school in Physics at the University of Illinois, Urbana-Champaign.

Tristan Rocheleau worked on a project called "The Search for Intersubband Plasma Instabilities". He is going to graduate school in Physics at Cornell.

A student from Howard University was an undergraduate intern, summer 2004, and worked on computer interfacing for persistent optical charging of self-assembled dots.

A student from UC Berkeley was a summer 2004 scholar in the UC LEADS Program, working on fabrication of robust Cryogenic electrical test apparatus.

An undergraduate student worked on infrared spectroscopy of persistently-charged self assembled quantum dots.

Petra van Koppen

Four undergraduate students were hired as program coordinators, Jan-June 2005. They set up the lab for each outreach workshop and organized and helped train outreach program volunteers. They maintained our outreach website, <http://www.chem.ucsb.edu/~outreach/> and the outreach email account, outreach@chem.ucsb.edu . Because of the large number of students, parents, and teachers who participate in our program, the undergraduate coordinators are essential. Their enthusiasm, motivation, and willingness to help have been an invaluable asset to the program. In addition to the UCSB undergraduate coordinators, approximately 30 to 40 UCSB undergraduate students and 3 graduate students volunteered in our outreach program.

The program coordinators and all the outreach volunteers are an inspiration to many students, teachers and parents in the community every year. The volunteers have indicated that the outreach program is a valuable opportunity to teach and share ideas for teaching effectively. This year, one of our outreach coordinators and one volunteer have been accepted into the Teach for America Program.

Alec Wodtke

Chris Larson worked on the AFOSR grant

AWARDS AND OTHER ACTIVITIES

Guenter Ahlers

Dr Ahlers was elected a Fellow of the prestigious American Academy of Arts and Sciences. <http://www.ia.ucsb.edu/pa/display.aspx?pkey=1144>

Jeffrey Bode

Dr Bode was one of four young faculty members to receive the prestigious CAREER award from the National Science Foundation.

<http://www.ia.ucsb.edu/pa/display.aspx?pkey=1262>

Frank Brown

Dr. Brown received the prestigious Sloan Research Fellowship from the Alfred P. Sloan Foundation for this year. <http://www.ia.ucsb.edu/pa/display.aspx?pkey=1258>

He also received a Presidential Early Career Award in Sciences and Engineering (PECASE). This award is UCSB's first PECASE in the sciences and only the second ever awarded to a UCSB faculty member. It is also the first time a UCSB faculty member has been chosen by the NSF for the award.

<http://www.ia.ucsb.edu/pa/display.aspx?pkey=1310>

Thomas C. Bruice

Dr. Bruice received the National Academy of Sciences Award in Chemical Sciences

<http://www.ia.ucsb.edu/pa/display.aspx?pkey=1234>

Mattanjah DeVries

Humboldt Fellowship

Gordon Conference Chair

Two publications made the cover of their respective journals

Peter Ford

Dr Ford was elected President of the InterAmerican Photochemical Society (2004-06)
Allergan Distinguished Lecturer--Calif State Univ. Long Beach October 2004

Song-I Han

Dr Han was invited to give a talk at the Gordon conference which is a very high honor. 06/06/2005: Invited Lecture, S. Han, "Remote Detection of NMR and MRI", Gordon Conference on Magnetic Resonance, Connecticut College, New London, USA.

Dan Little

Dr. Little takes an especially active role in training undergraduate researchers. For these and other aspects of his teaching efforts, Dr. Little was named the UCSB Chemistry Departments' "Outstanding Faculty Member" by Student Affiliates of the American Chemical Society.

Petra van Koppen

Dr. van Koppen received the Mortar Board Professor of the Year Award, February 3, 2005 and the California Legislature Assembly, Certificate of Recognition for Materials Chemistry Outreach, June 6, 2005

Center for Terahertz Science and Technology Annual report for July 1, 2004 to June 30, 2005

Globally, activity in the field of Terahertz Science and Technology continued its rapid increase in the past year. During the last fiscal year, I co-organized a workshop on Opportunities in Terahertz (THz) Science, and co-authored a report based on the workshop. The report can be found on the Department of Energy's Basic Energy Sciences website at <http://www.sc.doe.gov/bes/reports/list.html>. Perhaps because of this report, we have had an increasing number of outside users interested in doing research at the Center, tapping into the expertise of its researchers and its unique facilities, including its Free-Electron Lasers. In addition, local researchers continue with cutting-edge research, most of which is in semiconductor physics.

One of the collaborative enterprises is on the THz dynamics of polymer crystallization. The ideas for the science to be investigated, and the idea to use the UCSB Free-Electron Lasers, come entirely from Prof. Jing Wu at the New Jersey Institute of Technology. He contacted us more or less "out of the blue." Preliminary experiments conducted by him in collaboration with our staff physicist Jerry Ramian were sufficiently promising for him to write a proposal to the NSF, which has been funded. The existing faculty and staff at the UCSB FELs are providing technical support and building an instrument for this experiment. This research is pioneering in that it will be the first application of high-power THz radiation to the enormous field of polymer science.

Another exciting collaboration is with the National High Magnetic Field Laboratory (NHMFL), based in Tallahassee, Florida. Drs. Louis-Claude Brunel and Hans van Tol, staff scientists at the NHMFL, are expert in electron spin resonance (ESR). They are part of a team which plans to build a Free-Electron Laser at the National High Magnetic Field Laboratory, and they are considering building one very similar to UCSB's FEL. One of the uses of the FEL at the NHMFL will be to perform ESR measurements in the highest steady-state magnetic fields on earth. The frequency of ESR increases in proportion to the magnetic field, and requires THz radiation at magnetic fields produced at NHMFL. ESR is a very important tool in physics, chemistry and biochemistry. The highest frequency commercial instruments run below 0.1 THz. Running at higher frequency will enable new science, including the elucidation of biologically-important high-frequency dynamics of proteins and other biological molecules. Since it will be many years before the FEL in Florida will be built, they are working with us to develop a unique capability to perform pulsed ESR at 0.24 THz in a 9 Tesla magnet that they will bring to UCSB. We will hear more about this exciting collaboration in future annual reports.

The development of new technology for security applications has also engendered collaborations with scientists at the Lawrence Livermore National Laboratory, and with a company called Passport Systems, Inc.

For this year's research highlight, I will briefly describe a result from my own group that is a milestone on the road to developing quantum information processors using Terahertz radiation. The field of quantum information processing is attracting some of the most talented researchers in disciplines including mathematics, computer science, many branches of physics, electrical engineering, materials science and chemistry. For several years, my research group has been

working towards developing a quantum information processor in which the information is stored in one of two quantum states of an electron bound to an impurity or a “quantum dot” in a semiconductor. The frequency required to make a transition between these states is near 1 THz. One of the requirements for a useful quantum bit is the ability to determine its state (whether it is a logical 0 or 1) with high fidelity. Measurement in quantum mechanics is a notoriously difficult problem, as illustrated in Heisenberg’s well-known uncertainty relations. Graduate student researcher Dan Allen has made a breakthrough in developing a technique which uses a near-infrared (slightly longer wavelength than visible) laser read out with high fidelity whether electrons bound to impurities are in their ground state (logical 0) or not. This work was published in an article entitled “*Optically Detected Measurement of the Ground-state Population of an Ensemble of Neutral Donors in GaAs,*” by D. G. Allen, M. S. Sherwin, and C. R. Stanley, Phys. Rev. B **72**, 35302 (2005).

Statistics for the Center for Terahertz Science and Technology

Number of research publications: 10

Number of invited talks: 12

Number of FEL accelerator hours logged: 1,387

Ph. D.s granted: Matt Doty, Sam Carter, Kulvinder Gill

Research projects:

1. Terahertz electro-optics in semiconductor nanostructures
2. Optical Manipulation of Quantum Information in Semiconductor Nanostructures.
3. Development of a THz source based on Bloch oscillation in semiconductor superlattices.
4. Development of THz detectors based on intersubband transitions in quantum wells
5. Development of THz detectors based on 2-D plasmons in quantum wells
6. Terahertz dynamics of polymer crystallization
7. Biological Sensing with Terahertz Circular Dichroism Spectroscopy
8. Submillimeter-Wave Circular Dichroism Spectroscopy of Biomaterial in Water
9. Development of a Stable, User-Friendly, High-Power Terahertz Source: Enhancements to the UCSB Free-Electron Lasers.
10. Non-intrusive identification and imaging of materials in shipping containers (through business agreement with Passport Systems, a high-tech company based in Boston).

FEL users from UCSB:

Undergraduate student researchers:

Tristan Rocheleau (Advisor: Sherwin)

Graduate student researchers:

Matt Doty (Advisor: Sherwin)

Sam Carter (Sherwin)

Dan Allen (Sherwin)

Sangwoo Kim (Sherwin)

Jing Xu (Allen, Plaxco)

Post-doctoral researchers:

Brendan Serapiglia (Sherwin)

Pavlos Savvidis (Allen)

FEL users from outside UCSB:

Prof. James Heyman (Macalaster College, St. Paul, MN)

Prof. Jing Wu (New Jersey Institute of Technology)

Agilent Labs

Tomas Feil (University of Regensburg, group of Prof. W. Wegscheider)

Raytheon

Shigeki Kobayashi (University of Tokyo, group of Prof. H. Sakaki)

Passport Systems

Six-month sabbatical visitor to Center for Terahertz Science and Technology

Prof. Dr. Hartmut Roskos, University of Frankfurt. He is a very prominent and active researcher in the field of Terahertz Science and Technology, and worked on developing a THz source while he was at UCSB.

CENTER FOR NONLINEAR SCIENCE

Bjorn Birnir, Director

The mission of CNLS are scientific investigations that are driven by recent advances in mathematics. By using recent developments in mathematics problems in the physical sciences that have remained unsolved due to lack of mathematical tools can be solved and the new insights gained by doing this invariably lead to new mathematics.

In the 1980ties and 1990ies the mathematical driving force was the rapidly developing dynamical systems theory, first for ordinary differential equations (ODEs) and then for partial differential equations (PDEs). For the first few years of the twentieth century advances in Stochastic PDEs (SPDEs) and complex dynamics are providing a new driving force.

The research areas in CNLS include:

Turbulence and the associated invariant measures that provide the statistical theory of turbulence. These these theories are compared with direct simulations of the Naviers Stokes Equations (DNS).

Landsurface evolutions, modeling, theory and simulations and the development of similar analysis for earthquakes.

Simulations of schools of fish and other migrating animals in biology. Theory, simulations and comparison with experiments.

Mathematical physics, the development of noncommutative PDEs and their applications in string theory. Theory and simulations.

Nonlinear dynamics in quantum systems and design of complex materials.

Theory and simulations of flow and flow control in jet engines.

The UCSB faculty and postdocs participating in the Center's activities include:

Björn Birnir, Mihai Putinar, Xu-Dong Liu, Gustavo Ponce and Carlos Garcia-Cervera in Mathematics, Terrence Smith in Geography, Ralph Archuleta and Daniel Lavallee in Geology, Jeffrey Moehlis and Robert McMeeking in Mechanical Engineering and Roger Nisbet in Biology and Gilliaume Bonnet in Statistics and Probability.

Two postdoc in Mathematics have worked in CNLS, Niklas Wellander and Helena McGaghan and many graduates students.

The many activities in CNLS include:

a weekly seminar run jointly with Applied Mathematics.

There is currently one NSF postdoc Helena McGaghan and a Swedish Science Foundation postdoc Niklas Wellander just completed his training. Several visitors have spent up to a month at CNLS, Kim Sneppen from the Niels Bohr Institute, Thordur Jonsson and Larus Thorlacius from the University of Iceland and Nordita.

CNLS is participating in the UC scholarship repository and graduate students from Mathematics, Biology, Mechanical Engineering and Physics are doing research at CNLS.

CNLS is organizing an International Conference in Berkeley in Dec. 2005 jointly with MSRI the NSF research institute in mathematics. Funds were obtained from NSF and NSA.

Bjorn Birnir gave popular lectures in Santa Barbara and Goleta, at schools and retirement communities on Chaos and Fractals.

One SGER (high-risk big-benefit) grant from NSF was obtained by Birnir and he was invited to give a series of lectures on Nonlinear Quantum Dynamics in Madrid in 2004.