SRI REU 2006 Student Projects and Program Activities

REU 2006 Students during field trip at a Silicon Valley company

Project Descriptions

Erica Bolin (University of Florida)

Mentors: Drs. Tom Slanger and Richard Copeland

Laboratory Studies of Processes Important in the Oxygen Airglow

Erica worked with Chris Mullen to study the possible reaction of the $O_2(c)$ state with carbon monoxide to produce CO_2, an interaction that we have proposed could be important in stabilizing the CO_2 atmospheres of Venus and Mars. Particularly in the case of Venus, where fairly exotic chemistry is used to explain the low levels of CO and O_2, the proposed reaction could provide a marked simplification of the mechanism.

The project involved a two-laser experiment, where the excitation laser generated vibrationally

excited levels of the $O_2(c)$ state from O_2, while the second laser probed the population and decay of the $O_2(c,v)$ level initially produced, as well as that of lower levels. A variety of background gases were used, including CO, to establish the collisional losses in the system. This work represented a first cut at the problem, because the vibrational level of primary interest is the v = 0 level, whereas Erica's study concentrated on the v = 9-11 levels, their production and detection being much easier.

Erica was able to measure the $O_2(c, v = 9\text{-}11)$ collisional loss rates for the quenchers CO, O_2, N_2, and CO_2, finding that they were all fast, exceeding 1×10^{-11} cm^3s^{-1}, and that typically the loss rate coefficient increased with vibrational level, although this was not true with CO_2. Because the levels surveyed are still far removed from v = 0, subsequent work must develop techniques that permit investigation of that level.

Erica's work provided kinetic data for systems where none had previously existed. She learned a lot in the process, and gave a nice talk on the project at the end of the summer. Tom Slanger presented the work at the DPS meeting in Pasadena in October 2006.

Ashley Diehl (University of Rochester)
Mentors: Drs. Sanhita Dixit and Gregory Faris
Optical Imaging for Cancer Detection

We are studying a new method for detection of cancer based on infrared imaging. The hemoglobin in blood provides strong contrast for infrared imaging in the body. This contrast can be modulated by inhalation of mixtures of oxygen and carbon dioxide, which change the hemoglobin absorption spectrum and cause blood vessels to expand or contact. Tumors can show a different response than healthy tissue because of the nature of the blood vessels. To grow larger than roughly 100 microns, tumors must create their own blood supply through a process called angiogenesis. These tumor blood vessels are generally tortuous and leaky, and can exhibit a different response to gas inhalation than healthy tissue. Experiments performed during the summer included studies of the response of tumors in rats during a preprogrammed gas inhalation cycle and analysis of the time-varying results using MATLAB.

Kevin Kauweloa (Linfield College)

Mentors: Drs. Jeanne Haushalter and Gregory Faris

Tumor Boundary Detection Using Fluorescence

During excision of a cancerous tumor, it is important to know the precise extent of the tumor. A tumor that is not removed completely can form the basis for recurrence of the cancer. On the other hand, removing too much healthy tissue is not desirable either. This project is intended to develop a method for determining the boundaries of tumors using optical imaging. This approach uses the processes that occur during tumor growth. There is an enzyme active at the tumor boundary that stitches proteins together to provide a framework for the new tissue. We use fluorescent infrared dyes to label proteins or peptides that are acted on by that enzyme. This will produce a fluorescent region along the boundary of the most recent tumor growth, allowing clear definition of the tumor boundary. The work performed focused on development of microtiter-plate assays for the activity of fluorescently labeled substrates to the enzyme activity.

Erica Krivoy (Carnegie Mellon University)

Mentors: Drs. Abneesh Srivastava and Gregory Faris

Stimulated Scattering Measurements in Supercritical Fluids

When intense light from a pulsed laser interacts with matter, the light can elicit a nonlinear optical response. One type of nonlinear optical response is stimulated scattering, in which the intense light causes a tremendous increase in the amount of scattered light from atoms or molecules. We use stimulated scattering to measure inherent properties of matter including chemical properties (using stimulated Raman scattering from vibrational and rotational modes), elastic properties (using stimulated Brillouin scattering from acoustic modes) and thermal properties (using stimulated Rayleigh scattering from thermal modes). We have been adapting a new method for stimulated scattering measurements based on frequency-offset techniques. This has included both electrical homodyne detection and Fourier transform detection and examination of a number of frequency offset techniques.

Emma O'Neill (Haverford College)

Mentors: Drs. Brian Sharpee and Tom Slanger

Probing the Storm-Time Atmosphere with Optical Spectra from Astronomical Instrumentation

MPL researchers have pioneered the use of spectra of the terrestrial night airglow, obtained from high resolution spectrograph on large astronomical telescopes, to study the kinetics and composition of the nighttime atmosphere. However, most of these spectra were taken at low latitude, precluding similarly detailed examination for auroral components that arise from altitudes different from those where the bulk of the quiescent nightglow originates. To determine what spectra of a potentially disturbed atmosphere might reveal, Emma O'Neill reduced and analyzed spectra from the HIRES echelle spectrograph on the 10-meter Keck I telescope in Hawaii and the UVES instrument on the 8-meter Kueyen Telescope (Very Large Telescope Array) in Chile, taken during and in the immediate aftermath of the major geomagnetic storm of October 29-November 1, 2003. Emma manually reduced one of two nights of HIRES data from raw images to intensity and wavelength calibrated spectra, and made progress towards doing the same for the first of five nights of UVES data, learning the specifics of the instrument's software reduction pipeline. While the HIRES spectra, taken in the aftermath of the storm, appears to be similar to those of the quiescent atmosphere, the UVES spectra, taken during the storm, exhibits features rarely seen and of much greater intensity than in quiescent nightglow. These features' appearance roughly coincides with increased geomagnetic activity and precipitate flux as gauged by geomagnetic indices, indicating potential auroral activity. However, the predominance of atomic species emissions such as N(^2P-^4S), O+(^4S-^2D), and Ca+(4p ^2P -4s ^2S), as compared to molecular species, such as the N^{2+} First Negative 0-0 band, is more similar to a phenomenon known as a "cusp" aurora, than to a standard aurora where molecular species dominate.

Anand Oza (Princeton University)

Mentors: Drs. Kostas Kalogerakis and Jochen Marschall

Studies of the Ammonia Ice Clouds in Jupiter's atmosphere

Observational evidence and thermochemical models indicate an abundance of ammonia ice clouds in Jupiter's atmosphere. However, spectrally identifiable ammonia ice clouds are found covering less than 1% of Jupiter's atmosphere, notably in turbulent areas. Current literature

suggests two possible explanations: coating by a hydrocarbon haze and/or photochemical processing ("tanning"). We have been testing these hypotheses by laboratory studies of ammonia ice films. Our experiments during the past couple of years have indicated a consistent suppression of the 3-μm NH3 ν_3 asymmetric stretch feature with increasing coverage by thin layers of benzene or other hydrocarbons. To interpret the recent experimental results, Anand developed a multi-layer thin-film optical modeling code based on a recursive approach. The modeling simulations have reproduced the experimentally observed suppression effects and demonstrated the important role of optical interference. Anand presented his results at the Fall 2006 meeting of the American Geophysical Union in San Francisco in San Francisco.

Byung Chul Pak (University of California San Diego)
Mentors: Drs. Abneesh Srivastava and Gregory Faris
Lanthanide Chelate Bioassays

Lanthanide chelates have a number of useful properties for performing bioassays including long-lived excited states, narrow emission profiles, and no photobleaching. The low optical efficiency of lanthanides can be overcome using surface-enhanced lanthanide luminescence in which the proximity between a noble metal nanoparticle and a lanthanide ion leads to a very large enhancement in lanthanide luminescence, by one or more orders of magnitude. The enhancement occurs from the enhanced electric fields produced by the oscillation of free electrons on the metal nanoparticle, called the surface plasmon resonance. By coupling one probe molecule to the nanoparticle and another to an organic ligand holding the lanthanide, one can detect when the two probes are brought close to each other. In this way, we can examine molecule interactions or identify the presence of specific molecules such as proteins or DNA. Work was performed on methods for preparation of silver nanoparticles, coating the particles with protein and fluorescent labels, and measuring the optical response of the particles.

Arseny Vasilyev (University of California, Davis)
Mentors: Drs. Sanhita Dixit and Gregory Faris
Optical Microfluidics

Microfluidic techniques offer the ability to perform large numbers of experiments or assays in a small area with very good detection limits and small use of reagents. We are exploring a type of

microfluidics based on manipulating small droplets using light, which is an alternative to microfluidics techniques using channels. Droplets are contained in a solvent or oil, forming an inverted emulsion. The droplets have been moved using either the radiation pressure of light (optical trap or optical tweezers) or using laser heating to change the local surface tension (thermal Marangoni effect). Over the summer, we investigated the effect of surfactants on the manipulation of droplets. Surfactants naturally self assemble at the interface between water and solvent or oil, forming a layer that can help isolate the droplet from the oil.

Arthur Prindle (California Institute of Technology)
Mentor: Dr. Harald Oser

Headspace Analysis for the Identification of Bacteria

As bacteria grow it is known that they release a variety of volatile compounds. These compounds can be used for the identification of the bacteria. We have developed a sampling protocol based on Solid Phase Micro Extraction (SPME) that collects volatile organic compounds from the headspace above the bacteria culture. These samples are subsequently analyzed by GC/MS. During the course of the project we determined the headspace composition of different bacterial cultures at different times and different environments. The goal of the project is to identify bacteria-specific molecules which can be used for the pre-symptomatic identification of infection and also to help to understand the formation of the volatiles found.

Allison Widhalm (University of Southern California)
Mentors: Drs. Brian Sharpee and Tom Slanger

Analysis of Data From The Keck 10-Meter Telescopes

Large ground-based astronomical telescopes simultaneously record light from stellar objects and from the earth's nightglow, a faint emission that originates with the chemistry of the upper atmosphere. Astronomers find this glow to be an annoyance, and do their best to make it go away, but in fact it contains an enormous amount of information on atmospheric processes, and is proving to be a valuable resource to aeronomers studying the atmosphere. We take advantage of the superb tools used by the astronomers to obtain the highest quality spectra ever obtained of the night sky. These spectra contain emissions from oxygen atoms and molecules, nitrogen

atoms, sodium, potassium, and OH. The OH emission is intense, and its study is important, as it relates to atmospheric temperature, chemistry, spectroscopy, and dynamics.

In addition, the large telescopes have been used to study the atmosphere of Venus, and we have found both similarities and differences in the emission from the two environments, with the common thread being emission from oxygen atoms and molecules. We study the various emissions from both the earth and Venus to learn how the atmosphere changes in an hour, a night, a season, and a solar cycle. Work on this project involves learning how to handle the data files, and represents a unique opportunity to explore our environment as made accessible by the world's largest telescopes. A grant from NSF's Planetary Astronomy Program (REU supplement) supported Allison's research.

SRI MPL REU Program Activities

1. Tutorial Seminars

The REU program at the SRI's MPL has weekly meetings throughout the summer. During the first half of the summer, the SRI staff or guest speakers present a series of 45-minute seminars. In addition, several other opportunities for seminars are available within SRI departments.

Date	Time	Speaker	Seminar Title
June 15	11:00 AM	Dr. Peter Mazzone (Cleveland Clinic)	Lung Cancer: Background, Challenges, and Opportunities
June 22	11:00 AM	Dr. Edhan Prabhu (FlexEnergy)	Catalytic Microturbines
June 27	7:30 PM	Prof. Sarah Church, Stanford/KIPAC	Whispers of the Big Bang
July 13	11:00 AM	Dr. Elizabeth Gerken (SRI)	Remote Sensing of the Upper Atmosphere by Imaging Sprites and HF-Induced Airglow
July 17	11:00 AM	Dr. Ripudaman Malhotra (SRI)	Global Energy: The Crisis Upon Us
July 20	2 PM	John Benemann (Intl. Network on Biofixation of CO_2 and Greenhouse Gas Abatement)	Algae Biofuels
August 3	7:00 PM	Dr. Uwe Bergmann, SLAC	Archimedes: Ancient Text Revealed with X-Ray Vision
August 9	1:00 PM	Dr. S. Julio Friedmann, Carbon Management Program, LLNL)	Technology needs for a carbon management economy
August 11	10:30 AM	Dr. Laura Mazzola (CEO, Excellin)	A Novel Platform for Cell Engineering
August 17	11:00 AM	Dr. Michael Wong (UC Berkeley)	Nitrogen on Jupiter—Clouds and Cosmochemistry

2. Student Presentations

All the students present their work at the end of the summer. These presentations last approximately 20 minutes, with an additional 10 minutes reserved for questions and discussion. The following is the schedule of student presentations for the summer of 2006:

Date	Time	REU Student	Seminar Title
August 15	4:00 PM	Erica Bolin	Excited State Chemistry and Atmospheric Stability for CO_2 Planets
August 15	4:30 PM	Kevin Kauweloa	Tumor Boundary Detection Using Fluorescence
August 16	4:00 PM	Erica Krivoy	Stimulated Rayleigh Scattering in Liquids
August 16	4:30 PM	Emma O'Neill	Nightglow Emission in Storm-Time Atmosphere
August 24	4:00 PM	Ashley Diehl	Optical Imaging for Cancer Detection
August 24	4:30 PM	Anand Oza	Studies of the Ammonia Ice Clouds in Jupiter's Atmosphere
September 7	10:30 AM	Byung-Chul Pak	Surface Enhanced Fluorescence of Lanthanide Chelates Using Silver Nanoparticles
September 7	11:00 AM	Arthur Prindle	Bacterial Detection and Identification based on Volatile Metabolites using Gas Chromatography-Mass Spectrometry
September 7	11:30 AM	Arseny Vasilyev	Optical Microfluidics

3. Academic / Industrial Visits in 2006

a) On July 7, we had a tour at the Stanford Linear Accelerator Center in the afternoon, followed by a visit at SLAC's Kavli Institute of Particle Astrophysics Center. There, we attended presentations by graduate student Fabio Iocco and postdoctoral fellow Dr. Melanie Bowden on nucleosynthesis and cosmic background radiation, respectively.

b) On July 14, Dr. Regis Vincent SRI's Artificial Intelligence Center introduced us to the robotics technologies they are developing and we witnessed a live autonomous robot demonstration.

c) On July 25, we were given a tour of SRI's laboratory animal facility by the facility's manager Nonie Esteves and learnt about relevant research performed by the Biosciences Division.

d) On July 28, we had the opportunity to visit Prof. Robert Byer's group at Stanford's Applied Physics Department. We attended brief presentations from several graduate students and potdoctoral fellows and then visited the laboratories (host: Karel Urbanek)

e) On, August 4, we held our own REU lab tours: Each student gave a brief oral overview of his or her project in the laboratory (or by the computer for one computational project). Each presentation lasted approximately 5 minutes with another 5 minutes for questions. The students were asked to cover briefly their project and why they do it, and then focus on how they do the experiments and the instrumentation used.

f) During the weekend of August 4-6, the Molecular Physics Laboratory hosted a symposium/reunion to celebrate its 50^{th} anniversary. The students participated in all scientific and social activities of this symposium.

g) On August 8, we visited SRI's Engineering Group and had an introduction to SRI's artificial muscle and telepresence robotic surgery technologies (hosts: Roy Kornbluh and Bruce Knoth).

h) On August 14, we were hosted at Lam Research Inc., a Silicon Valley company manufacturing equipment for plasma etching of silicon wafers. Dr. Jorge Luque,insert title here, gave us a presentation of the company and a tour of the company clean room. Under the guidance of Lam staff, our group performed a simple plasma etching procedure on a silicon wafer.

4. Social Events

Besides several weekend outings and activities the students organized on their own, we hosted the annual summer pool party, birthday parties for the students who had their birthdays in the

summer, various “happy hour” and pizza lunches, payday bagel meetings, and a farewell gathering. In addition, the students attended several SRI events (e.g., New Staff luncheon, meeting with SRI’s CEO, SRI Summer BBQ, SRI Postdoctoral Fellow Meetings, etc.).