

## SRI REU 2007 Student Projects and Program Activities



REU 2007 students during visit at the Stanford Linear Accelerator Center

## Student Research Projects and Accomplishments

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### **Radiative Cooling of the Earth's Atmosphere by Nitric Oxide**

Maija Benitz (Colorado College)

*Mentor: Dr. Richard Copeland*

The most tangible accomplishments from this summer are the direct research goals that I accomplished. We determined a rate constant for the self-relaxation of  $\text{NO}(v=3)$  at room temperature which agrees with one value in the literature and rejects the others. We are planning to publish our results in *Chemical Physics Letters*. Additionally, I was able to study the self-relaxation at lower temperatures using dry ice and liquid nitrogen.

On more of a personal, and less project related note, I accomplished a lot of intangible goals. I am far more confident in my lab skills at the end of this summer. I feel comfortable running

experiments on my own, from turning on the lasers to analyzing the data. I learned how to use Origin this summer, and how to analyze my data with an understanding of what the results actually mean.

This summer also presented me with a lot of lessons in chemistry, quantum mechanics and atmospheric physics. This included lessons from my own project, other REU students, weekly seminars and fieldtrips.

I learned a lot about the process and nature of scientific research this summer. It was a great experience to be a part of the planning and implementation of an experiment, as well as the analysis and subsequent planning for future experiments. I learned a lot about the frustrations and obstacles in scientific research, as well as the excitement of finally getting an experiment to work.

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### **Silver Nanoparticle Enhanced Luminescence for Proximity Bioassays**

Traci Brooks (Austin College)

*Mentors: Dr. Gregory Faris*

The goal for my project this summer was to try and create a set protocol to use when constructing a stable nanoparticle to attach a lanthanide label. One of the main factors in creating a stable nanoparticle is the distance that exists between the silver nanoparticle and the label. In the process we determined four different methods to try and achieve stability. The methods are using MHDA, ez-link, DTSSP, and DNA. Each linker helps to functionalize the nanoparticle and offers a different distance between the nanoparticle and the dye.

Using these ideas, we have been working on discovering which distance provides optimal fluorescence and stability. We have learned about the nature of silver nanoparticle, how the nanoparticles react with varying amounts of the linkers, and the manner in which the linkers attach to the nanoparticles. All of the information collected this summer will be used to discover the appropriate amount of linker to add to the nanoparticles and to help produce a more accurate protocol for constructing stable and functionalized nanoparticles.

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### **Optical Microfluidics**

Alhaji Cherif (Cornell University)

*Mentors: Drs. Gregory Faris and Sanhita Dixit*

A compelling need currently exists for rapid and inexpensive methods of detecting pathogens, diagnosing and prognosticating disease, developing new drugs, and performing genetic analysis. To meet these needs for processing large numbers of samples at high speed (high throughput), considerable interest has been placed on microfluidic devices, also called “lab-on-a-chip.”

Much of the work on microfluidics to date has involved production of patterned fluidic circuits, a relatively direct analogy with microelectronics. An alternative approach involves unconfined

movement of individual droplets. While fluidic circuitry is the microscopic equivalent of tubing or pipes, droplet motion is a closer analogy to the individual droplet delivery obtained with pipettes, the mainstay of the macroscale chemistry and biology laboratory. We have recently discovered a new method for control of small droplets using laser heating based on the thermal Marangoni effect. This approach should be applicable to a variety of applications in chemistry and biology using small volumes and large numbers of samples. Current research is directed toward performing molecular analysis in small volumes with a goal of performing analyses of large numbers of individual cells in reaction chambers not much bigger than the cells themselves.

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### **Vibrational Energy Transfer in OH( $\nu$ )**

Zachary Geballe (University of Michigan-Ann Arbor)

*Mentors: Drs. Richard Copeland, Kostas Kalogerakis, and Gregory Smith*

I determined several previously unknown removal rate constants of OH( $\nu = 4$  and  $3$ ) by O<sub>2</sub> and CO<sub>2</sub> at a variety of temperatures from 140 K to 300 K. I verified that O<sub>2</sub> indeed becomes a much more efficient quencher of OH(4) at lower temperatures, increasing four-fold from 300 to 140 K. I found that temperature dependence of OH(3) removal rates mimic those of OH(4) by O<sub>2</sub> and CO<sub>2</sub>. I found out that in order to determine the branching ratio from OH(4) to OH(3) for any quencher, we need to use a different setup. To avoid the big scatter that causes gives way too much error in the critical early times, we probably need to use a different chemical reaction to produce OH(4), which may eliminate the usefulness of knowing the branching ratio from  $\nu = 4$  to  $3$ . Nearly everything about the experimental setup was established before I arrived. Nevertheless, I confirmed that the setup works for  $\nu = 3$  (with a filter centered at 315 nm), and that even an undergraduate can reproduce the removal rates that SRI had determined previously - a very rigorous check, right? :-). Also, I found that it is easy to hold the cell's temperature around 190 K with a PVC pipe and a 2 cm thick piece of blue foam, but that it requires more attention to stabilize around 165 K with the same setup...but that I am capable of attentiveness.

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### **High-Speed Frequency Domain Camera for Time Resolved Bioimaging**

Kameron Harmon (Arcadia University)

*Mentor: Dr. Gregory Faris*

The most beneficial part of my project was the fact that it forced me to stretch myself and learn, something which I had no previous experience in. Not only was I given an introduction to new skills but I also met a variety of people from all over the world. Through meeting these people it helped me understand what I want to do and the field of study that I want to go into.

I feel that my progress was correct for the task at hand. Having no prior experience in programming in VHDL, it was a slow start but as things went along the process became easier and easier. From the goals that I set up at the beginning of the summer, I was unable to complete all of my goals, but I am satisfied in the amount of work that I was able to

accomplish. The one thing that I have learned about the scientific method is that it is a never-ending process of troubleshooting and rebuilding so that you can get a wide spectrum of data that can then be compared to other research. The one thing that tended to shock me the most was the amount of money that goes in to the projects. What I have learned has shown me the field that I want to work in and has also furthered my understanding of research and development.

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### **Ozone Photodissociation Experiments**

Matt Hoffman (University of Puget Sound)

*Mentors: Drs. Dusan Pejakovic and Tom Slanger*

This summer, I accomplished many of the goals I set forth at the beginning of June. Dusan and I completed the upgrade of our apparatus, including installing a new grating into the monochromator, adding a photon counter to the data acquisition system, and installing a periscope to change the orientation of the light coming from the cell. We also calibrated both the intensity of our data acquisition system and the wavelength of our monochromator.

Each of these steps was just a part of obtaining a signal from ozone's photodissociation into  $O_2, b_1 \Sigma_g^+$ . We recorded a spectrum that showed clearly defined peaks that were larger than the noise, a great success, considering how small the fluorescence from the  $O_2, b_1 \Sigma_g^+$  signal.

Lastly, we began to look at the time decays of these signals, again using the photon counting method. Although we just began this process, it seems to have good potential to show these decays and let us calculate the rate constants. We have not looked at  $v > 3$  yet, but this work will be done after I leave.

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### **Laboratory Studies of Ammonia Relevant to the Outer Solar System**

Ajeeta Khatiwada (McNeese State University)

*Mentors: Drs. Kostas Kalogerakis and Jochen Marschall*

This summer I worked in the research project titled Study of Ammonia Ice Relevant to Outer Solar System with Kostas and Joe. Our goal was to develop a methodology in order to measure the optical constants for ices at HeNe and Infra Red wavelength using Laser Interferometry and FTIR spectroscopy methods respectively.

During the beginning of the summer, I had submitted my project goals where I had written about how we are going to develop a methodology to measure the optical constants of the ammonia at HeNe wavelength. When we started the project, we first did the similar experiment for water in order to check the reliability of our apparatus. Our approach was good in a sense that the values of refractive index that we got for water closely resembled the values that we could find in literature for water and also the values of refractive indices that we got for different growth rates

were quite consistent. So, after testing our method and apparatus we started similar experiments for ammonia and benzene.

While depositing the ices in the cryostat, we were also using FTIR spectrometer in order to see absorbance spectra for the ices at IR wavelength. We also simulated similar absorbance spectra for water using the thickness of the film that we obtained by Laser interferometry method, temperature and the optical constants at similar conditions. Our future plan is to develop a similar computer program where we can input the absorbance spectra, temperature and film thickness in order to get the values of optical constants at IR wavelength. From the experiments we did this summer, we already have the necessary infrastructure in order to get the values of the optical constant using this approach, the only task that has remained is to modify the existing program in order to make it suitable for our project.

Unlike what I used to think before, the experience this summer has taught me that when we do actual research, we might not always end up doing what we had expected to do in the beginning. The road of research is unpredictable and one actually has to face all the challenges that come on the way and eventually it will take us to the ultimate destination. Doing research is not only about solving the mystery that we are interested in but in this process we might also have to deal with other mysteries that surround it. So, like I had hoped in the beginning, this REU experience has helped widen my horizon of knowledge about physics along with many other essential things in life.

Apart from the project accomplishments, this summer I also got to learn a lot about academic as well as social things through the conferences, talks and the discussions at SRI. This summer research experience has been a milestone in my life for widening my perception.

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## **Laser Vaporization of Explosives for Remote Detection**

Brian Krancevic (The Ohio State University)

*Mentors: Drs. Gregory Smith, David Huestis, and Harald Oser*

This summer I worked on a project entitled ‘Laser Vaporization of Explosives for Remote Detection’. The point of the project was to try a new method to detect materials with low vapor pressures. We did not actually use explosive materials for this; we used laser dyes dissolved in a solvent instead.

The summer started out with me reading more than a few journal articles about explosives detection as well as the effects of lasers heating surfaces. After having sufficient background on the subject matter, Greg and I started putting together the apparatus we would use to do our experiments. This took a great portion of the summer as we needed to put together the experimental cell we would be using, align all the optics needed, and hook up the electronics needed for detection. There were a few snags in this process that took a while to work out but eventually we did get a good signal from our setup and were able to then do experiments.

The basic set up of the experiment was as follows: have a vacuum pumped cell with a surface that the laser dye solution was sprayed onto that could be rotated by a motor. A laser would

come in perpendicular to the surface and evaporate off the dye into the cell and then a laser would come in parallel to the surface and do laser-induced fluorescence, which could be detected by a photomultiplier tube.

Some of the things we were interested in learning about this summer were what materials would work for our experiment, what laser powers would make the process work, and how much dye needed to be on the surface to be detected. So we did various trials to find those things out, and then I gave some results in the presentation.

I think I learned a lot about the process of research. I learned not everything goes very smoothly all the time and that there are a lot of meticulous, sometimes tedious, things that need to be done because they are important. One of the most exciting things I learned was the feeling of success in a new experiment that one is not sure will work; it is a great feeling indeed to see signal from something for the first time. So those are just a few lessons I will take away with me from this summer, and I will always have fond memories of this summer.

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### **Tumor Boundary Detection Using Fluorescence**

Stephanie Olson (Hamline University)

*Mentor: Dr. Gregory Faris*

The long-term objective this project is to be able to clearly map the boundary between a tumor and the healthy tissue that surrounds it. My part in the experiment was to help improve the imaging system. There were many aspects that had room for improvement. The previous system used included a low-powered laser diode, which created shadowing. The new high-powered LEDs will reduce the shadowing and fewer patterns are formed. The person experimenting had the tedious task of covering the system with a cardboard box and fabric, as well as having to turn off the lights. The new light-tight box eliminated this problem altogether. The rats will be more comfortable while lying horizontally, as opposed to being strapped onto the paddle and imaged vertically. This also greatly reduced the amount of slipping and moving of the rats, which will make our results more accurate. Last was the front panel of the main program used for imaging controls the filter wheel. The files are also saved in a standardized format, with use of a file-saving LabView Sub-VI. The front panel now has an increased viewing window of the image, and the most frequently used controls at hand, without the need to scroll.

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### **Differential Optical Imaging for Cancer Detection**

Maya Sen (Columbia University)

*Mentors: Drs. Sanhita Dixit and Gregory Faris*

The basic goal behind differential optical imaging is to detect a response from the stimulus in rodents that were either implanted with a cancer cell line or not. In our case, we looked at the response in hemoglobin of whole body rodents (not just a specific region) as they breathed various gases. From stimuli, there were changes in the transmitted intensity because

deoxygenated and oxygenated hemoglobin are chromophores. Hemoglobin in particular absorbs around 780 and 840 nm. Our focus is the change, the difference between the transient and baseline responses, and is the reason why we use differential imaging.

Our first step was to image the rodents immersed in an index matching liquid. With these raw images, we attempted to extract a small signal from the low signal to noise ratio, after reducing the dimensionality with principal component analysis. If the extraction was successful (i.e., no blank image), then it means the response signal was maximally aligned with the indicator function. The indicator function image, obtained from principal components, represents the best representative image (response image) of the specific gas inhaled by the rodent. The indicator function is only usually when the stimulus and response are not correlated. Further tests are necessary to determine how successful this method is for animals. In addition, the technique may be a potentially useful way to detect cancer in clinical 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	Speaker(s)	Seminar Title
6/4/07	SRI, LBNL, LLNL, PARC, Sandia, EPRI, Technology Ventures Corporation, UC Davis, Stanford	2007 California Clean Tech, Open Innovation Partners Program, Technology and Entrepreneur Matching Event
6/8/07	Dr. Dan Held, SRI	Neutralizing Botulinum Neurotoxin with Human Polyclonal Antibodies
6/12/07	Dr. G. Scott Hubbard, SE	Exploring Mars
6/13/07	Dr. Tom G. Slanger, SRI	Planetary Airglows
6/14/07	Dr. Carl D. Meinhardt, UCSB, SpectraFluidics LLC	Free-surface microfluidics for detection of airborne explosives
6/19/07	Dr. Sarah Demers, SLAC	The Large Hadron Collider: Redefining High Energy
6/20/07	Dr. Ahu Akin, SRI	Studies of Electron Dynamics Using Photoelectron Spectroscopy
6/28/07	Dr. Ripu Malhotra, SRI	Global Energy: The Crisis Upon Us
7/11/07	Dr. David L. Huestis, SRI	Probing the Earth's Ionosphere by Incoherent Scatter Radars
7/19/07	Dr. Gregory P. Smith, SRI	Weakly Bound Atmospheric Molecules
7/25/07	Dr. David L. Huestis, SRI	Earth, Venus, Mars, and the Greenhouse Effect
8/7/07	Dr. Sanhita Dixit, SRI	Constructing Artificial Lipid Bilayers Using Optical Microfluidics
8/10/07	Dr. Bin Chen, SETI and NASA Ames	Raman Spectroscopy Applications and Instrument Development in Materials Trace Detection and Characterization
8/22/07	Dr. Sanjeevi Sivasankar, UC Berkeley and LBNL	Single Molecule Optomechanics: Watching and feeling biomolecules
8/28/07	Dr. Marusa Bradac, SLAC	The Dark Side of the Universe



## 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 2007:

Date	REU Student	Seminar Title
8/13/2007	Alhaji Cherif	Optical Microfluidics
8/13/2007	Kameron Harmon	High-Speed Frequency Domain Camera for Time Resolved Bioimaging
8/13/2007	Ajeeta Khatiwada	Laboratory Studies of Ammonia Relevant to the Outer Solar System
8/14/2007	Traci Brooks	Silver Nanoparticle Enhanced Luminescence for Proximity Bioassays
8/14/2007	Zack Geballe	Vibrational Energy Transfer in OH( $\nu$ )
8/14/2007	Matt Hoffman	Ozone Photodissociation Experiments
8/15/2007	Stephanie Olson	Tumor Boundary Detection Using Fluorescence
8/15/2007	Maya Sen	Differential Optical Imaging for Cancer Detection
8/16/2007	Maija Benitz	Radiative Cooling of the Earth's Atmosphere by Nitric Oxide
8/16/2007	Brian Krancevic	Laser Vaporization of Explosives for Remote Detection

### **3. Academic / Industrial Visits in 2007**

- On July 6, 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 fellows Drs. John Wise and Marcelo Alvarez.
- On, July 12, 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.
- On July 27, we visited Thermo Fisher Scientific in San Jose. Our hosts Drs. Jean-Jacques Dunyach and Eloy Wouters gave us a lecture and a tour of their division, which involved in the design and manufacturing of mass spectrometers, ion sources, and ion traps.
- On August 3, Dr. Regis Vincent of SRI's Artificial Intelligence Center introduced us to the autonomous robotics technologies his group is developing and we witnessed a live autonomous robot demonstration. Then, engineers Bruce Knoth and Harsha Prahlad gave us lectures and tours of the telepresence robotic surgery project and the artificial muscle laboratory.

### **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.).