



SRI Molecular Physics Laboratory REU 2004 Students

Christina Baer (Wellesley College)

Mentors: Drs. Dušan Pejaković and Kostas Kalogerakis

Experimental Investigations Relevant to the Upper Atmosphere: Deactivation of $O(^1D)$ by $O(^3P)$

These experiments are designed to probe the processes involved with collisions between different excited states of oxygen at very low pressures, a condition that mimics the upper atmosphere. In the thermosphere, mesosphere, and stratosphere (different layers of the upper atmosphere), molecular oxygen, O_2 , is photodissociated into atomic oxygen, O , due to ultraviolet radiation from the sun. A laboratory version of this process can be created using an artificial source of UV radiation; in my case this source is a 157 nm fluorine laser. In the atmosphere, the combined emissions of molecular oxygen in several excited states produces an effect called

nightglow.

A green line located at 557.7 nm can be distinguished in spectra of the nightglow. The appearance of this line, characteristic of oxygen, demonstrated that the airglow could be associated with the photodissociation of O_2 . In addition, another spectral line characteristic to oxygen is visible in the nightglow spectra, located at ~630 nm. While referred to as the “red line,” this spectral feature actually consists of two separate red lines occurring at 630 and 634 nm.

In my experiments, atomic oxygen is produced by the photodissociation of molecular oxygen at 157 nm, the product atomic states are $O(^1D)$ and $O(^3P)$. The transition from the excited $O(^1D)$ state to $O(^3P)$, the ground state, produces a 630 nm emission (the red line) which can be detected by a photomultiplier tube (PMT) with the help of an interference filter or a monochromator. By varying the intensity of the laser light or composition of gas in the cell, it is possible to control the concentration of atomic oxygen in the resulting gas mixture. The evolution of the $O(^1D)$ concentration over time will be determined by studying the time dependence of the red line intensity. From this data, it is possible to determine the $O(^1D) + O(^3P)$ rate coefficient.

As of August 20th the initial experimental goals determined for this summer have been met. Despite our difficulties maintaining laser power from day to day, we managed to take data which allows us to calculate a preliminary rate constant for the deactivation of $O(^1D)$ by $O(^3P)$. Our initial values indicate that the constant is about 2 orders of magnitude slower than previously thought. Many more experimental checks must be made before we are certain that our data actually corresponds to the $O(^1D)+O(^3P)$ collision. Analyzing the data and coming to understand the theory behind the $O(^1D)$ experiment was a truly valuable experience; forcing myself to work through the differential equations was not particularly pleasant but my understanding of the processes underlying the experiment definitely improved. In addition to working on the $O(^1D)+O(^3P)$ experiment, I also had the opportunity to work with Rhiannon on her experiment concerning ammonia ice and hydrocarbons. It was a great opportunity for me to be involved with such different experiments; taking data on both setups exposed me to many different experimental techniques and allowed me to have more hands-on time in the lab. I only wish I had more time to follow through with my experiments, I feel like I've come to a deeper understanding of my experiment just in time to leave. I have really enjoyed working for Kostas, his enthusiasm, patience and inherent teaching ability greatly enriched my entire experience at

SRI. The REU program offered me the chance to work with professional scientists in a research environment, an opportunity that is not available at Wellesley. Participating in experiments and interacting on a daily basis with the scientists in MPL allowed me to see what a career as a research scientist entails and I can't emphasize enough the importance of that experience.

Zachary Campbell (Texas A&M University)

Mentors: Drs. Dušan Pejaković and Richard Copeland

Laboratory Studies Relevant to the Airglow

The project I worked on this summer involved laboratory studies of processes relevant to the upper atmosphere. Specifically, we investigated vibrationally excited molecular oxygen in its ground and first excited electronic states. These studies were funded by NASA, and are relevant to observations carried out by the SABER instrument of the TIMED satellite. Knowledge gathered from this project will further our understanding of the emission from vibrationally excited water molecules in the mesosphere, enabling the remote monitoring of H₂O concentration profiles.

Laboratory experiments were performed on mixtures of N₂, O₂, O₃, and CO₂ gases. We excited the oxygen molecules in the mixture with one laser and detected the excited molecules with a second laser. We used REMPI (Resonance Enhanced Multiphoton Ionization) techniques in which only a particular excited species was ionized and detected by measuring the ion current. Varying the delay between the laser pulses allowed us to study the dependence of the concentration of particular O₂ excited states.

In the first part of the project, I became well acquainted with the experimental apparatus and assisted Dr. Dušan Pejaković and Dr. Rich Copeland in performing measurements of the rate constants of the reactions O₂ (*X*, *v* = 1) + O and O₂ (*a*, *v* = 1) + O. In the second part of the project, I independently performed measurements of the rate constants of the reactions O₂ (*a*, *v* = 1) + O₂ and O₂ (*a*, *v* = 1) + CO₂ at temperatures of 240 K and room temperature. Our measured room temperature rate constants are consistent with earlier SRI measurements, and the O₂ (*a*, *v* = 1) + O₂ rate constant does not show significant variation between room temperature and 240 K. However, the O₂ (*a*, *v* = 1) + CO₂ rate coefficient at 240 K is ~20% lower than that at room temperature.

Yu Gu (Cornell University)

Mentors: Drs. Kenneth Kotz and Gregory Faris

Optical Microfluidics

Microfluidics is a new technology that has the potential to revolutionize analytical chemistry and biotechnology. Previously at SRI, we had demonstrated a droplet-based microfluidics technique using an Argon laser beam to move droplets containing water and red dye. My goals for this summer were to reconstruct the setup and reproduce previous results with an infrared laser beam. Using the infrared laser is advantageous over using the visible beam because the IR beam is non-destructive and does not require the use of a dye since it's directly absorbed by water.

I have accomplished three goals this summer. 1) I built a setup with a tunable diode laser with a range of 1520-1580nm, an Erbium-doped fiber amplifier, and a custom-designed microscope. 2) I showed that water droplets from 100um to 1mm could be moved and combined using the infrared beam. 3) I repeated a simple protein detection assay performed earlier by Ken (Horseradish Peroxidase + ABTS) with the new setup. I have also started the design process for performing further molecular analysis. In particular, I have done drawings for the creation of a doughnut-shaped beam using an axicon lens. The first eight weeks of the summer were devoted to building the setup and the microscope. I spent three weeks performing experiments and brainstorming about molecular analysis.

Future work includes increasing the range in droplet size, maintaining a high contact angle, and facilitating molecular analysis.

Andy Knyazik (University of California-Santa Cruz)

Mentors: Drs. Kenneth Kotz and Gregory Faris

Stimulated Rayleigh and Brillouin Spectroscopy

Stimulated scattering occurs due to light – matter interactions. The two types of stimulated scattering phenomena that we tried to measure this summer were Rayleigh and Brillouin scattering. Brillouin scattering is produced when light scatters off an acoustic wave, whereas Rayleigh scattering is due to light scattering from entropy or thermal waves. These measurements can be used to determine bulk properties of materials such as density, mixing fraction, compressibility, speed of sound, temperature, acoustic damping rate, dynamic viscosity

and thermal diffusivity.

My goal for the summer was to build an apparatus that will be used to demonstrate effects of Rayleigh and Brillouin Spectroscopy in supercritical fluids. The name of the technique is stimulated gain spectroscopy, which is when a powerful pump beam interferes with a probe beam. The signal spectrum of the probe beam is then measured, in which I plan to see traits of Rayleigh and Brillouin scattering. Throughout these 12 weeks, I intended to learn a lot about optical equipment and its practical applications, by using it to create our apparatus. I learned to work with mirrors, lenses, spatial filters, isolators, amplifiers, polarizers, half- and quarter-waveplates, and fibers. I believe I have achieved most of my goals for this summer, as I will illustrate below.

I have built a system that took the output of an Nd: YAG laser operating at 1064 nm, separated it into probe and pulse beams, and interfered these in a sample cell further along the optical path. To create a pump beam I double passed a weak narrow-band laser through two gain amplifiers operating at 10 Hz. I optimized the two spatial filters that followed each gain amplifier, which would only keep the desired fundamental spatial mode passing through and block all other amplified modes. The probe laser was generated from the seed laser with a beam-splitter. I sent the probe beam through a single-mode fiber to filter out unwanted modes, and later on focused it inside a cell, where it interfered with the focused pulse beam. The probe beam then went inside another fiber where the output was monitored with a photodiode connected to an oscilloscope in order to detect the scattering of interest.

Optimizing the amplification while keeping lasing under control took a lot of time, and therefore I did not collect any scattering signals inside supercritical fluids. The losses that the probe beam has when it passes through a single mode fiber are also very disappointing: I am only getting 25 to 30% of the power through the fiber. The apparatus otherwise is optimized and is done well enough to perform the scattering measurements.

Rhiannon Meharchand (Florida State University)

Mentors: Drs. Kostas Kalogerakis and James Boulter

Spectroscopic Characterization of Ammonia Ices Relevant to the Atmosphere of Jupiter

This summer, I performed spectroscopic characterization of ice mixtures of ammonia and hydrocarbons. This involved extensive use of infrared absorption spectroscopy and cryogenic temperatures. My main goal was to learn how to use the apparatus, perform certain experiments, and increase my knowledge of all data collection and analysis techniques. I am proud to say: mission accomplished (sort of).

I began the summer by trying to climb the steepest learning curve imaginable. I spent a lot of time figuring out what spectroscopy was, and why on Earth (or Jupiter, for that matter) anyone would need it. I also spent a good deal of time familiarizing myself with the apparatus, and trying not to break things. I learned about Jupiter, and quite a bit about various spectroscopy experiments that had taken place with ammonia. Everything was quite confusing in the beginning, but things started to work out for the better as the summer continued.

By mid-summer, I had figured out how to run experiments by myself and not break too many things (although I'm pretty sure the ion gauge and turbo-molecular pump hate me a little). I spent a lot of time collecting data, in an attempt to figure out how to get spectra that look like the literature. There were also a few weeks during the middle of the summer where I attempted to figure out what the data meant and where to get the constants and figures needed for calculations. This led me to the conclusion that Google hates me a little too.

Throughout the summer we took various trips to companies and research facilities in the bay area, which was very enlightening. I had never seen the for-profit/industrial side of research, and I feel like a whole new horizon of opportunity was laid out for me during our trips.

The end of summer rush was exhilarating. Experiments started to work, things started to make sense, and I started to become a little sad that everything would be ending soon. All considered, I discovered the following things:

- 1) It is possible to obtain and suppress ammonia features in the infrared absorption spectra by coating the ammonia films with hydrocarbons.
- 2) 12 weeks may seem like a long time, but it is nothing in the world of research.
- 3) I like the world of research.

I never quite believed that this was a field that I could go into, but this summer has shown me that anything is possible once you just get over how little you know and jump in headfirst. I'm much more confident in my abilities now, and much more aware of what skills I will need for the real world. I had a wonderful summer, made a lot of new friends, and discovered a little bit about myself in the process. Thank you so much for the opportunity.

Nader Moussa (North Carolina State University)

Mentors: Dr. Jochen Marschall

Thermal Properties of Polycrystalline Ultra-High Temperature Ceramics

This summer, I worked with Dr. Marschall to develop a computational model of thermal properties of polycrystalline Ultra-High Temperature Ceramics. This model was developed to explain experimental uncertainties in laboratory samples of the material by exploring the parameters that affected net material properties. The model implemented a large network of crystalline grains, statistically distributing constituent materials of the UHTC into an interconnected lattice. Further developments included accounting for alignment and anisotropy of the crystal grains, alternative geometry and connectivity of the network, and exploration of the conduction and resistance to heat transfer between individual cells.

Some of the difficulties I faced this summer involved the implementation of the computer model. I worked in FORTRAN-77, which was a good experience with scientific computation, very different from my school curriculum in computer science (which is geared towards "modern business programming" techniques). The idiosyncrasies of this language provided a fun challenge. I also applied many techniques from diverse fields to implement my geometric model, which used Truncated Octahedron shapes instead of cubes for the individual ceramic grains. Turning these complex shapes into program-code exercised my skills in vectors and matrices. Lastly, I developed a good understanding of the timing, scheduling, and other issues involved in a research environment. These skills are independent of the project I worked on, and will be very portable to future work.

My experience at SRI was fantastic. The work was stimulating and fun; the environment was conducive to productivity, with a great deal of self-direction. This gave me the opportunity to work at my own pace, which I think made for a balance between productivity and learning. In

summary, I enjoyed working here this summer, and will definitely consider coming back in the future.

Adam Percival (Reid College)

Mentors: Drs. Jeanne Haushalter, Xudong Xiao, and Gregory Faris

Upconverting Chelates

Upconverting chelates are a new type of optical reporter, recently invented at SRI. In the process of upconversion, two lower energy photons are absorbed by a lanthanide ion that is held by a chelating agent. A higher energy photon is then emitted and detected. These chelates can be attached to an antibody, which makes them useful in biological assays such as detecting the presence of viruses. Upconverting chelates are potentially extremely useful for biological imaging as their use produces no autofluorescence, they are small, have low phototoxicity, and do not photobleach. While there are other reporters that exhibit some of these capabilities, such as single-photon fluorescence, upconverting phosphors, and downconverting chelates, upconverting chelates offer unique capabilities compared to these alternative methods. The overall goal of the upconverting chelate research at SRI is to demonstrate their feasibility as a biological reporter.

The primary goal of the summer was to complete an upconverting chelate-based immunoassay in a microscopic format including matrix effects for a cell culture. Completion of this assay would meet the requirements of our funding milestone, allowing further work in this area to proceed. To assist in achieving this goal, I performed a number of experiments. For erbium chelates, I helped investigate different chelating agents (DPA, DTPA, and DOTA) and excitation mechanisms (one-color excitation at both 810 nm and 980 nm, as well as two color 810 nm plus 980 nm). We found that we could produce upconversion using all three excitation methods, and that the best chelating agent was DPA, followed by DTPA and then DOTA.

Secondly, we spent some time investigating the potential of silver island films to enhance the signal from lanthanides. In preliminary experiments using Eu-DTPA, we were able observe an increase in signal strength by a factor of ten in the chelate solution on a silver island film slide, as compared to an ordinary glass slide. In addition, we observed a significantly decreased fluorescence lifetime in the chelates on a silver island film compared with those on glass, as

predicted by the theory of silver nanoparticle enhancement of electromagnetic fields. This provides us with further experimental confirmation that we are observing a true enhancement of our signal from the silver island film.

Finally, I performed a number of experiments relating to a co-fluorescent solution that can be used for enhancing the signal from our chelates. Despite difficulties in reproducing the results from our experiments, and a number of problems resulting from europium contamination, we were able to consistently show a significant increase in our signal strength due to the co-fluorescent solution. Unfortunately, to date it has been difficult to quantify this enhancement and determine our detection limit, due to poor reproducibility. We also are not yet certain of the extent of the europium contaminant in gadolinium of different purities, or of how the signal strength changes as the europium concentration varies. As a result, the co-fluorescence technique is not quite to the point where it can be really useful in our assay, although several experiments that attempt to resolve these issues are currently in progress.

Núria Queraltó (Ramon Llull University, Spain)

Mentors: Dr. Jochen Marschall

Oxidation of High-Temperature Ceramics

Stability of materials is an important issue in the reentry of spacecrafts into the atmosphere. Molecular oxygen is dissociated by the shock wave generating atomic oxygen which can interact with the surface in two ways: (i) either it can recombine and, with the exothermic energy of this reaction, heat the materials, (ii) or it can oxidize the surface materials because atomic oxygen is very reactive. Resistant materials are therefore needed to build spacecrafts. Ultrahigh temperature ceramics (UHTC) like HfB₂/SiC or ZrB₂/SiC have an extremely low vapor pressure and resistance to oxidation. Additionally they are extremely hard and melt at high temperatures. This combination of properties makes UHTC an interesting candidate for building spaceships.

In order to study all these processes I've been involved this summer in the research project "Oxidation of refractory ceramics in dissociated oxygen" with Dr. Jochen Marschall. My main goal was to study the effect of dissociated oxygen on the oxidation of Si, polycrystalline SiC and LPCVD Si₃N₄. These systems are less complicated than UHTC and allow a better understanding of the processes involved in the oxidation.

One of the steps was to investigate the oxidation environment because we really didn't know how many oxygen atoms are involved in the process. We ran some experiments measuring pressure and temperature at different points of the system. We have concluded that to know exactly the amount of oxygen atoms we would need a laser technique. In any case, we have estimated the loss of oxygen atoms due to the recombination process along the tube.

Another step was to run some experiments changing the oxidation conditions like time or temperature. With these results we have been able to fit the data to the oxidation equation of Deal and Grove. From this part we have extracted some rate constants that have helped us to understand better the overall process.

We have used two gases to obtain atomic oxygen: molecular oxygen (O_2) and nitrogen oxide (N_2O). The first one was less dissociated than the second one because the bond between the nitrogen and the oxygen of the nitrogen oxide is weaker than the bond of the molecular oxygen, which is not 100% covalent. According to this, when we used N_2O instead of O_2 the samples were more oxidized.

There's a lot of controversy about which is the species that is diffusing through the silica layer. Everybody argues about three candidates: O_2 , O , O_2^- . After reading in the literature we believe that molecular oxygen is the one diffusing. In this hypothesis atomic oxygen remains in the surface when we dissociate the molecular oxygen and then recombines into molecular oxygen and diffuses.

Nevena Rakuljic (University of California, San Diego)

Mentors: Drs. Ken Kotz and Gregory Faris

Optical Imaging for Cancer Detection

Optical Imaging for Cancer Detection is a research project based on the use of the optical systems to detect growing tumors in rodents. In order to grow, tumors create blood vessels through a process called angiogenesis. Unlike healthy vessels, these vessels of the tumor neovasculature leak, have abnormal branching, and misdirected flow. Due to these anomalous anatomical structures, tumors tend to have oxygenation characteristics that differ from the surrounding tissue. Using spectroscopy, and the fact that near infrared light passes through the tissue easily, one can look at the hemoglobin and determine oxygenation status.

There are two measurement techniques that are used at SRI to characterize a tissue—a CW imaging and fiber optic frequency domain instrument. My job this summer has been working on the imaging setup for the frequency domain. I built a light intensifier circuit which detects light coming out of the rodent that allows us to separate absorption from scattering, and thus to quantify the characteristics of a tissue. The modulation frequency of the light and the detector is in the 100 MHz range. The detector is based on modulating the gain of an image intensifier at a frequency offset from the modulation of our source light, which allows us to look at the heterodyne detection of the signals.

The intensifier acts as a mixer of the frequency offset optical signal and the 100 MHz amplified signal. This information allows us to compare RF amplitude and phase before and after entering the tissue, as well as the change in DC amplitude. Plugging this information into the frequency domain equation, we are able to quantify the values of absorption and scattering of the tissue, which are the numbers that we seek.

The stability of the light source that has been mentioned in my goals statement has been addressed as well. Moreover, as we have realized, laser diodes are stable enough for our experiment (in terms of temperature), and thus all that needs to be done is purchase a couple of diodes at different NIR wavelengths, with the necessary power of 1 Watt or more.

I have been imposed with many problems that I had to solve, such as impedance matching, dealing with RF pick-up and increasing the modulation depth of our signal. My electronics background has helped me, but without help of my mentors would not have been sufficient to successfully complete this portion of the project. Working in SRI has definitely been beneficial to my future career, and has helped me get a better grasp in the field of applied electronics.

Brock South (Rose-Hulman Institute of Technology)

Mentor: Dr. Harald Oser

Selective Mass-Spectrometric Detection of Chemical Agents During Real-Time Air-Intake Monitoring

During my term at SRI, I worked with MPL's nanosecond laser photoionization time-of-flight mass spectrometer (TOFMS). The ongoing goal of the project is to apply this particular mass spectrometric technique to the problem of on-line chemical agent detection. In the end, the

project wants to turn out a system that can, for example, sit in an air intake and perform real-time monitoring of the incoming air, screening for deadly chemical agents. Currently, the search continues for the optimum method to use in order to detect chemical agents—the system must be sensitive, fast, and selective.

My contribution to this larger project for the most part dealt with improving the latter characteristic: selectivity. I set out to determine if the fragmentation patterns of the chemical agent simulant molecules change in a reproducible way as the wavelength of the ionizing photons changes. This could provide a highly selective means to identify particular agent molecules if there proved to be fragment pattern changes unique to each molecule. I collected and analyzed three-dimensional signal intensity vs. wavelength and mass spectra of two agent simulants under various conditions of temperature, laser focusing, and ionizing wavelength. The end result of my studies showed that each fragment of these simulant molecules behaved in the same way when the wavelength was scanned over the range of 270 nm to 250 nm. This means that there were no patterns appearing that could be used to uniquely identify the simulants in this wavelength region. Consequently, I showed that wavelength scanning in the investigated wavelength range was not a good route to take. My studies, however, opened up another possible route having to do with the power density of the laser beam in the ionization region which ultimately could greatly simplify the current system without limiting its potential usefulness as a detector.

In addition to my project goals, I had many personal goals for this passing summer. I was able to absorb knowledge pertaining to a variety of fields—organic chemistry, laser physics, chemical agent studies, and mass spectroscopy. I had never worked with or even seen a mass spec system before this summer, and I certainly had not even a clue how they worked. Now I can say that I have a comfortable working knowledge of time-of-flight mass spectrometers—at the least, I could probably pick up and use similar time-of-flight mass specs without much training or hassle. In working with this system, it was required of me to learn some simple organic chemistry naming rules. I had seen chemical names quite a bit in my schoolwork, but it wasn't until I sat down with them here that I actually figured out that they really do correspond well to the structure of the molecules. Also, while working with the system I became reasonably familiar with the mass spec's laser system. Over the course of the summer I picked up a great deal of knowledge about chemical agents—what they are, what they do, how to detect them, and so on.

If nothing else, that information is interesting, if perhaps not directly applicable in the near-term. What I will probably be using very soon, however, are the basic lab skills I honed during these months. These range from simple laser safety techniques to the habit of keeping a thorough lab notebook—honestly, the latter hadn't been a priority of mine until I learned firsthand the impossibility of keeping your figures and procedures just by memory even over the course of a week.

Indara Suarez (Pasadena City College)

Mentor: Dr. Harald Oser

Photoionization Studies of Explosives and Explosive Related Compounds

In cases where endangerment of civilians exists, such as landmines, it is necessary to have a rapid, selective, and sensitive method of detection for explosives and Explosives Related Compounds (ERCs). Due to the low vapor pressure and instability of the explosives, it is a challenging task to develop a fast method of detection. Current methods of detection are unsuitable for the rapid detection of these materials. The presented research examines the selectivity and sensitivity of the detection of explosives and ERCs and its limitations with the Resonantly Enhanced Multiphoton Ionization (REMPI) Time-of-Flight (TOF) Mass Spectrometer (MS) technique when combined with a tunable femto-second laser system. Previous experiments were done using a nanosecond jet-REMPI TOF MS system. These experiments showed that the parent molecule (ERC or explosive molecule) dissociates into fragments, mainly into NO, before ionization. These experiments were unable to show a significant difference between the NO fragments from the explosive (or ERC) and NO from compounds found in the atmosphere. In our current experiments, we utilize a femto-second Multi Photon Ionization (MPI) TOF MS system to successfully ionize the parent molecule before it fragments. This summer I set-up the first femto-second laser system at SRI. From the set-up, I learned many of the properties of each component of this system. I also learned about how different factors in the environment surrounded the system, such as temperature, influenced the performance of the system. Furthermore, I read many papers on systems similar to it and their perspective results when performing similar experiments. This allowed me to learn a lot about the structure of the molecules I was experimenting on and helped me understand the results. With the use of the femto-second MPI TOF MS approach we have obtained a distinguishable

mass spectral signature of the parent molecule itself. In addition to the parent molecule, we were also able to see some structural information in these spectra. Experiments done with nitrobenzene, nitrotoluenes (ortho, para, meta), and 1-3 dinitrobenzene. With the nitrotoluenes, the structural information in the spectra allowed us to distinguish between these three isomers. In the case of the ortho-nitrotoluene, we saw a clear signature of the ortho-effect, as our highest peak in the spectra was that of the parent molecule with an OH missing. The experiments done with the 1-3 dinitrobenzene were a bit trickier, since the 1-3 dinitrobenzene comes in crystals whereas the nitrotoluenes come are liquid. Since we were using an oven to increase the temperature of the molecules so that they would vaporize into a micro-meter capillary, which would then lead them into the ionization chamber, crystals caused a problem. We could not put the 1-3 dinitrobenzene crystals in solution because the solvent we used, methanol, introduced too much background noise. We decided to try to liquidize and vaporize the crystals in the oven. This was very successful, but it caused some problems. There was background noise from the air of the capillary, however it was only lower masses (highest air-mass was 63 amu). The other problem was that at times the crystals would get stuck in the capillary. At one point, we had to change it. The experiments performed with the 1-3 dinitrobenzene allowed us to map out the approach to molecules with lower vapor pressure (also in the form of crystals) like Trinitrotoluene (TNT). Also, since there is no previous literature on 1-3 dinitrobenze, these were some good preliminary results. And for the nitrotoluenes we were able to verify previous literature results. These were the first results obtained from the femto-second laser system at SRI. The next molecules we will approach with this system will be explosives, such as TNT and RDX. We will then extend the research to multi-mix real world samples, since the purpose of this research is to be able to apply it to the real world, and go beyond explosives, maybe to chemical agents. My experience at SRI was very fulfilling. In addition to learning a lot about this project, I learned about how research is carried through and how research teams work. I was also introduced to a new field in physics and will consider this field as a career option. I have walked out of SRI with more confidence as a student and with a variety of new knowledge.

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 astronomers 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.

SRI Molecular Physics Laboratory REU 2004 Program Activities

1. Tutorial Seminars
2. Student Presentations
3. Academic/Industrial Visits
4. Social Events

1. Tutorial Seminars

The REU program at the Molecular Physics Lab has weekly meetings throughout the summer program. During the first half of the summer, the laboratory staff or guest speakers present a series of 50-minute seminars that are tutorial in nature, giving the students an overview of the research conducted within the laboratory. The following is the schedule of seminars for the summer of 2004:

REU 2004 Tutorial Seminars

Date	Time	Speaker	Seminar Title
June 11	10:30 AM	Dr. Weilin Pan	Lidar Studies of Middle Atmosphere Phenomena
June 24	11:00 AM	Dr. Tom Baer (Arcturus CEO)	Presentation of Arcturus Bioscience Inc.
June 25	10:45 AM	Dr. Tom Slanger (SRI MPL)	Aeronomy by Astronomy
July 9	11:30 AM	Dr. James Boulter (SRI MPL)	Laboratory Investigations of Gas-Surface Reactions of Atmospheric Importance
July 16	10:30 AM	Dr. Gregory Faris (SRI MPL)	Stimulated Rayleigh and Brillouin Scattering
July 30	11:00 AM	Dr. Ben Rusholme (Stanford)	The Cosmic Microwave Background Radiation
August 20	10:30 AM	Dr. Ken Kotz (SRI MPL)	Near Infrared <i>in vivo</i> Imaging of the Dynamic Tissue Response to Vasoactive Compounds
August 20	11:30 AM	Joshua Mellon (OSU)	Electric Properties of Igneous Rock under Pre-Earthquake Conditions

2. Student Presentations

All the students are asked to present their work to 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 seminars for the summer of 2004:

REU 2004 Student Presentations

Date	Time	REU Student	Seminar Title
August 12	10:00 AM	Rhiannon Meharchand	Laboratory Studies of Ammonia Relevant to the Outer Solar System
August 12	10:30 AM	Nader Moussa	Simulating the Effective Properties of Polycrystalline Materials
August 12	11:00 AM	Allison Widhalm	Explosions in the Universe: Transient Sources in the Sloan Digital Sky Survey
August 18	11:00 AM	Zachary Campbell	Laboratory Studies Important in the Oxygen Airglow
August 18	11:30 AM	Adam Percival	Upconverting Chelates
August 19	11:00 AM	Christina Baer	Atmospheric Studies Using SRI's Vacuum-Ultraviolet Laser Facility
August 19	11:30 AM	Yu Gu	Optical Microfluidics
August 25	04:00 PM	Brock South	Laboratory Studies of Chemical Agent Simulants using Laser Ionization Mass Spectrometry
August 26	04:00 PM	Nuria Queraltó	Oxidation of Refractory Ceramics in Dissociated Oxygen
August 27	04:30 PM	Indara Suarez	Detection of Explosives and Explosives Related Compounds
August 26	09:30 AM	Nevena Rakuljic	Optical Imaging for Cancer Detection
August 27	10:00 AM	Andrei Knyazik	Stimulated Scattering Measurements in Supercritical Fluids

3. Academic / Industrial Visits

- a) On June 29, 2004, the students attended a public lecture entitled “Our lopsided Universe: The Matter with anti-Matter” (speaker: Steve Sekula, MIT/BABAR) at the Stanford Linear Accelerator Center (SLAC).
- b) On June 30, 2004, we visited and had a tour at SLAC in the morning, followed by a visit and tour of the laboratories of Profs. Steve Chu and Hongjie Dai at Stanford’s Bio-X, Applied Physics, and Chemistry Departments.
- c) Visit to Google Headquarters in Mountain View on (7/23/2004, host: Dyana Wong)
- d) Visit to Intuitive Surgical in Sunnyvale (8/2/2004, host: Tom Nixon)
- e) Visit to Arcturus Bioscience in Mountain View (8/12/2004, host: Tom Baer)
- f) Tour and operation of SRI’s Scanning Electron Microscope (SEM) Facility (7/28/2004, host: Jordi Perez)
- g) Visit to SRI’s Artificial Intelligence group and introduction to their robotics technologies (8/4/2004, host: Regis Vincent)
- h) Tour of SRI’s Engineering Demo Room and introduction to SRI’s artificial muscle and diamagnetic levitation technologies (8/10/2004, host: Roy Kornbluh)

4. Social Events

Besides several weekend outings and trips the students organized on their own, MPL hosted the annual pool party at the Huestis residence, two birthday parties for the four students who had birthdays in the summer, an ice cream “happy hour”, a pizza lunch and payday meeting, and two farewell gatherings. In addition, the students attended several SRI events (e.g. All-Hands meeting with CEO, New Staff luncheon, SRI Summer BBQ). Finally, MPL sponsored one weekend outing to Muir Woods and dinner in San Francisco.