

SRI REU 2011 STUDENT PROJECTS AND PROGRAM ACTIVITIES



SRI REU 2011 STUDENTS

Student Research Projects and Accomplishments.

Below is a summary of each student's project at the Molecular Physics Laboratory (MPL) at SRI International during the summer of 2011 in their own words with some editing of the text as appropriate.

Christina Porter (Reed University)

Mentor: Drs. Gregory Faris and Ashot Markosyan

Project Title: Frequency Modulated Stimulated Rayleigh Spectroscopy

My goal this summer was to implement a frequency modulated spectroscopy system that detects stimulated Rayleigh scattering, with Drs. Greg Faris and Ashot Markosyan. When I arrived, the optical elements of the pump-probe system were in place, but the electrical detection system was still in a rudimentary form. My first couple of weeks were spent learning about the optical system, and learning to align it (with more than 35 optical movable parts, this was not a trivial task). I then performed an alignment of the entire system on my own, which turned out to be quite stable, and we kept this alignment for the rest of the summer.

Our next goal – and a formidable one – was to actually detect a stimulated Rayleigh scattering signal. This took the majority of the rest of the summer to complete. We began with an

old LabVIEW program that ran scans in Greg's previous scattering setup, and tried to detect signal using a photodiode detector with two amplifiers and a bias tee. We originally looked at the entire RF part of the signal coming through our detector, and scanned the peak height of our probe beam as it moved through our pump beam's frequency on a fast Fourier transform. This revealed that we had a tremendous amount of noise – caused by RF interference, etalon effects, and ground loops – to battle before having any hope of detecting the Rayleigh scattering signal. We combated these issues by isolating many of our electrical elements from ground, removing elements that were causing etalon effects (an optical fiber cable with flat tips that behaved like parallel plates was making the cable act like a Fabry-Perot interferometer), and adjusting the alignment slightly to reduce ASE produced by the pump rods independent of the fiber laser source. After doing all of these things, we were able to decrease the noise on our scans by about thirty times, and after the adjustment to reduce ASE a shape appeared on our scans that we believed could possibly be our signal.

We then installed an I/Q demodulator with low-pass filters after our detector, which separated out the phase and gain elements of our RF. This showed a signal that lasted the duration that we were expecting, and looked like it might be what we wanted. However, we had to use a different oscilloscope for these new scan measurements and measure different things (the area under our waveform instead of the height of an FFT peak). So, I needed to rewrite our LabVIEW program to work with the new scope and take data differently before we could scan this new possible signal and find out if it really took the right shape. I did so, and the program fit our needs well. Using it, we got more hopeful scans. However, we still had a lot of RF interference muddling the possible signal. So we replaced our detector with one in a custom built, completely shielded box that encased the detector, bias tee, and amplifiers. In the course of building this detector box, I learned how to solder and became fairly proficient at it (which was one of my personal goals for the summer). When we installed this new detector box, it was immediately clear that we had indeed found our signal, in the shape that we were expecting. This was by far the biggest achievement of the summer, and it fortuitously happened the night before I gave my final presentation to the Molecular Physics Lab group.

After finding the signal, we overhauled the detection system yet again during the last two weeks when I was at SRI. Our system was flawed because it gave us phase imbalances in our signal, and depended significantly on the path lengths of our optical and electrical beams matching up. This gave us etalon-type effects and asymmetry in our signals. Greg then came up with an idea for a new detection system that would circumvent these issues, so our last major goal was installing it and getting the signal back in this new way. We managed to do so (which required completely changing all of the electronics on the detection side of our system), and we were able to get a better signal-to-noise ratio and more symmetric signal shapes that didn't have the same path-matching necessity. The system was then shot-noise limited instead of limited by electrical noise, which means that Greg may be able to perform full scans in a single pulse of the laser in the future, with a few modifications of the optical system. The new system still has some phase issues to be worked out, but it is overall a much better way to do the detection and getting it to work was another major success.

My last few days at SRI were spent working on data fitting (using Igor Pro), and creating schematics of the experiment apparatus and detection system. We developed macros that fit our signals to the theoretical curves, and got good fits. These fits are helping to elucidate the causes of the remaining phase issues with the new detection system. All in all, my research this summer

was very successful as SRI now has a fully functioning FM stimulated Rayleigh spectroscopy system with a strong signal to noise ratio.

Kendrick Campbell (Middlebury College)

Mentor: Drs. Konstantinos Kalogerakis and Oleg Kostko

Project Title: Excited Oxygen Atoms in the Earth's Ionosphere

Ionospheric modification experiments use observations of 630-nm red line emission from the radiation of $O(^1D)$ atoms decaying to $O(^3P)$ in conjunction with the equation for the total rate of relaxation of $O(^1D)$ to deduce the composition of the earth's ionosphere. Knowing the rate constants for the different possible reactions in that equation is imperative to correctly determine the composition. This summer we sought to measure those rate constants at temperatures ranging from 300 to 1000 K, thus learning their dependence on temperature.

To complete our goal, we needed to build an apparatus that would allow us to observe the emissions of $O(^1D)$ radiative relaxation. We modeled ours after a similar experiment conducted at MPL, that measured the relative yield of $O_2(b, v=0)$ and $O_2(b, v=1)$ when O_2 is incident upon $O(^1D)$ at room temperature. We began our work by trying to reproduce their results. This proved harder than originally thought, so we made our goals more immediate. Our new objective was to measure the relative yield at temperatures pertinent to the ionosphere. We also added on the task of determining the rate constant of $O(^3P) + O(^1D)$ at high temperatures from ionospheric heating observational data. We could compare that value with the value we hoped to determine in the lab.

We met all of our new goals, but not without obstacles.

In the lab we struggled to reduce our noise to signal ratio. First, we grappled with jumpy signal, which moved laterally on the oscilloscope with every trigger fire. Next we tried an array of optics systems to find a combination that let through maximum signal with minimal background. Our final setup to detect the $O_2(b, v=1)$ emission had a 7.62 cm focus lens, two RG 670 nm filters, a 630 nm filter, a 688.3 nm bandpass filter, a honeycomb, and another 9 cm focus lens before a photomultiplier tube. To detect the $O_2(b, v=0)$ emission we used a 9 cm focus lens, an RG 610 nm filter, an RG 715 nm filter, a 764 nm bandpass filter, two 760 nm bandpass filters, a honeycomb, and another focus lens of 15.16 cm before a photomultiplier tube. Gas flow proved to be a problem as well. We learned that the small tubes we used to pump gas through our cell failed to keep our chamber free of ozone and other contaminants, which spoiled our data. We replaced the small tubes with ones of a larger cross section to fix the flow rate.

Outside of the lab, we continued to have some difficulties. When attempting to fit our data, we found that the high speed of the decay of $O_2(b, v=1)$ resulted in a fit that heavily weighted towards the baseline because of significantly fewer points in the decay. Additionally, if the rise and decay were close in time, the selection of included data greatly influenced the fits. Our last issue with the data was the misalignment of the initial baseline of $O_2(b, v=1)$ emission and the final baseline of it. After some thought, we decided to use the final baseline as the zero for our fits. Although these problems caused a few unstable numbers in our fits, we took enough averages that we were able to generate confidence in our results, which were 0.77 for the relative yield of $O_2(b, v=1)$ for a temperature range of 300–520 K.

Finding dependable data proved to be the largest challenge to analyzing observational data from ionospheric heating experiments. Most had recorded the altitude poorly, which caused high uncertainty in the local temperature and composition of the ionosphere. In addition, because the

lifetime of $O(^1D)$ in the atmosphere is short due to collisions, we needed data taken every few seconds. The best we could find with good altitude measurements was recorded every 20 seconds. With that data, we determined a rate constant of $k_O \approx (3.4 \pm 0.4) \times 10^{-11} \text{ cm}^3 \text{ s}^{-1}$.

Since we have completed our immediate goals, we have returned to our initial ones. Currently in the lab, we are taking data to determine the rate constant of $O(^3P)$ relaxing $O(^1D)$. When we find this number, we can compare it to the number derived from the observational data to learn if they support each other.

Byron Tasseff (Northern Iowa University)

Mentors: Drs. Sanhita Dixit and Gregory Faris

Title: Droplet Lipid Bilayers

This summer, my principal research goal was to determine if droplet lipid bilayers (DLBs) produced via our optical microfluidic approach are of biologically relevant thickness. Although water transport across DLBs had been observed in previous REU students' experiments, the approximate thickness of the bilayers remained uncertain. Measuring our bilayers' permeability to hydrogen ions (protons) could provide a more reasonable estimate of DLB thickness.

To properly measure ionic flux across the bilayer, an electrochemical gradient first had to be established. To generate such an imbalance, lipid solutions with various pH levels (and thus various ionic concentrations) were prepared. Then, using our optical approach toward droplet manipulation, lipid bilayers were formed at the interface of two lipid monolayer-coated droplets, with an electrochemical gradient across the DLB. Using fluorescence microscopy in conjunction with the pH-sensitive fluorescent tracer dextran, fluorescein (whose emission intensity increases directly with pH), droplets were expected to undergo measurable changes in fluorescence (and thus hydrogen ion concentration) after bilayer formation. Such changes were recorded as a function of time, varying initial pH level, and droplet volume.

For my earliest experiment, lipid solutions of pH 6.61 and 5.05 were synthesized. Dextran-fluorescein was then incorporated into the pH 6.61 lipid solution. After forming a bilayer between two droplets of different pH, it was found that the fluorescent pH 6.61 droplet did not decrease in fluorescent intensity over a period of nineteen hours. Thus, proton transport across the bilayer was not observed. This implied the proton permeability of our bilayer was much lower than initially anticipated. To further investigate bilayer thickness, gramicidin A, a hydrophobic peptide which forms monovalent cation channels at the bilayer, was incorporated into lipid solutions of different pH. In my second experiment, after forming a bilayer between two different pH droplets, it was found that the fluorescence of dextran-fluorescein responded to proton transport across the DLB. Thus, with the incorporation of gramicidin in the bilayer, proton permeation was clearly observed.

In conclusion, with the incorporation of gramicidin into our droplet lipid bilayers, proton permeation was clearly observed. As the size of gramicidin dimers formed at the bilayer are similar in length to the thickness of natural lipid bilayers, our DLBs show high potential for future biochemical research. Further analysis of recent data will provide quantitative information related to DLB permeability.

Alexander Gvakharia (The College of William and Mary)

Mentor: Drs. Gregory Faris, Bin Guo

Title: Metal Nanoparticles for Multiplexed Bioanalysis

My goal this summer was to image nanoparticles and, determine their resonant wavelengths. We used metallic nanoparticles made from silver substrate, prepared using photoreduction techniques. The nanoparticles were on the 10-15 nanometer scale, and varied in wavelengths. Surface plasmon resonance, the oscillation of electrons on the surface of the metallic particles, is what's responsible for the nanoparticles displaying different colors. By imaging the spectra of the particles, we can categorize them by their resonant wavelengths and use them for tracking purposes. Cells can be labeled with colored nanoparticles and inter-protein interactions can be measured.

The first attempt at an imaging system was using a spectrometer. Light entered the spectrometer, reflected onto a grating which split the light into its spectrum, and then reflected it onto a camera. The grating could be adjusted to center on specific wavelengths. After debugging various hardware and software issues, I was able to get the spectrometer to image a spectrum, but the range of the spectrometer was not sufficiently wide for our purposes. The spectrometer had a range of about 220 nm, while I needed at least a 400 nm range to get the whole visible spectrum and some infrared lines.

I then switched to a prism set-up. The prism was now used for splitting the light into its spectrum. I had to calibrate the prism to plot wavelengths to corresponding pixel number on the images taken with the camera, by matching up known spectral lines to their location on the image. With the prism, we were able to get a range of about 700 nm, much better than the spectrometer. The wavelength to pixel mapping on the spectrometer was a linear relationship. Although the prism had a cubic relationship, more lines could be imaged onto the camera with the prism.

I then worked on making a LabView program that would process the images we took. The program would move the microscope stage, take an image of the spectrum, and then subtract the background and normalize it. It would then scan through the image and save it if it found spectral lines, by checking for pixel values above a threshold value. By the end of the summer I had the program able to do all but the final scanning through the image. Once that is complete, the program will be able to quickly collect spectra for nanoparticles and get the resonant wavelengths, facilitating multiplexed imaging.

Sumana Raj (Cornell University)

Mentor: Drs. Kontantinos Kalogerakis and Oleg Kostko

Title: Excited State Oxygen Atoms in the Ionosphere

This summer's research goal was to determine the $O(^1D) + O(^3P)$ rate constant, k_O , at high temperatures in order to better model the ionosphere. $O(^1D)$ is an excited state of the oxygen atom that plays an important role in the ionosphere but whose reactions are poorly understood. Examining this and other reactions of $O(^1D)$ will help to better characterize the composition and dynamics of the ionosphere. To find this rate constant, the experimental cell had to be created and the system had to be tested for accuracy by confirming the rate constants for previously studied reactions at low and high temperatures. These reactions include the reaction of $O(^1D)$ with N_2 at various temperatures, and with $O(^3P)$ at room temperature. Time permitting, the high temperature ratio of $O_2(b, v = 0)$ and $O_2(b, v = 1)$ produced from $O(^1D)$ colliding with O_2 was to be found as well. While some of these goals were met, the focus of the project shifted from $O(^1D) + O(^3P)$ to $O(^1D) + O_2$.

Problems first arose because the laser, not having been used for some time, was running with a very low energy per pulse. For a few days, the laser was run to warm it up and flush out impurities. However, a problem with the laser optics was also found which prevented the energy from becoming much higher. This being the case, it was decided to study the $O(^1D) + O_2$ reaction first, since it required lower laser energy than the other experiments. Therefore, after the cell was built, the room temperature rate constant for O_2 ($b, v = 1$) collisions with O_2 was measured. The collision of $O(^1D)$ with O_2 yields O_2 ($b, v = 0, 1$) (b_0 and b_1) and the $O=2$ ($b, v = 1$) will then collide with ground state O_2 still in the cell. The first few trials did not yield the expected value, and the optics before the photomultiplier tube (PMT) had to be adjusted. Different interference filters were used and a honeycomb was inserted to decrease noise. Before the optics were adjusted, different gas pressures were used and the flow meters were tested to ensure that these were not causing the problem. During this time it was also decided to detect a different b_1 emission than before. This was done to eliminate the possibility of leakage of b_0 signal into the PMT. Once these changes were made, the accepted room temperature rate constant was found.

The cell was then modified to include two PMTs, to simultaneously record both the b_1 and b_0 signals, and heating tapes, to adjust the temperature of the cell. It was also necessary to cool the flanges of the cell so that the electronics attached to the cell would not be damaged at the high temperatures. At high temperatures different gas flows were tested and both argon and a nitrogen and helium mixture were used as the bath gas. With 20 Torr of bath gas the measurements were successful and the ratio of the two species, b_0 and b_1 , was found to be approximately constant as the temperature varied. This ratio was determined through visually fitting simulations of the results to the data and finding the ratio corresponding to the best fit. However, varying the total pressure and attempting the experiment with only oxygen in the cell gave some unexpected results. Once these results have been fully analyzed and understood, the laser optics will be adjusted and $O(^1D) + O(^3P)$ data will be taken at high temperatures and using higher laser power.

Apart from experiments in the lab, old data was also analyzed with the goal of determining the $O(^1D) + O(^3P)$ rate constant at room temperature and incorporating the degree of dissociation into the analysis. This was successfully completed. The analytical solution for the $O(^1D)$ concentration as a function of time and with the degree of dissociation as a parameter was first found. Difficulties arose in determining the best way to write the solution in order to use it to fit the data with the program Origin. Origin had trouble fitting data using certain forms of the analytical solution, such as the full solution with rate constants and concentrations as parameters, so the optimal function had to be found. Finally, condensing the different physical values into four parameters led to a functional form that could be used to fit the data.

There were also problems determining the best way to estimate the degree of dissociation and so different methods were used. First, an average value of 0.75 was used. Based on the relationship between the initial signal and O_2 pressure, this estimate was determined to be too low and so 0.95 was used. Eventually, through analysis of data at different laser energies, the best estimate for the degree of dissociation was found. Other difficulties experienced during the data analysis included reducing the error in the parameter B . B is equal to $k_D - k_O$, where k_D is a linear combination of the $O(^1D) + O(^1D)$ collision rate constants. This error was reduced through the use of simultaneous fits of multiple data sets. Although successful analysis of $O(^1D)$ decay data was completed, there was less success with $O(^3P)$ rise data from the same experiments. The $O(^3P)$ rise data had much fewer points and the analytical solution for $O(^3P)$ as a function of time

was more complicated than that for $O(^1D)$. Because of these issues, the fits had much larger error and were very sensitive to initial conditions. Therefore, the decay data was used instead to determine k_O with little error. Still, even with these difficulties, with the correct estimate of the degree of dissociation and the analytical solution, k_O was found from the decay data.

Over the summer data was successfully taken and analyzed even though the initial goals for the project were modified. The focus of the laboratory experiments was changed from $O(^1D)$ collisions with $O(^3P)$ to collisions with O_2 due to the conditions of the laser. The b_1/b_0 ratio was successfully found at high temperatures, but work still needs to be done to fully understand the experiments. The data analysis fulfilled the initial goals for the project with some difficulties during the process. Additionally, the $O(^3P)$ rise data proved to be less useful than the $O(^1D)$ decay data for the determination of the rate constant. Although the rise data can still be used to find k_O , the resulting value had much larger errors than that found from the decay data. Now the original goal for the summer must still be accomplished, determining the high temperature $O(^1D) + O(^3P)$ rate constant.

Michael Rodriguez (California Lutheran University)

Mentor: Dr. Gregory Faris

Title: Microdroplet Generation for RT-PCR Analysis of Rare Cells

This summer, I worked on optimizing a system for creating droplet arrays on the nanoliter scale for use in biological assays. Instead of a very structured project focusing on a well-defined experiment where data is taken, I had a very open-ended problem where I had to tinker with a prototype system to gain an understanding of certain phenomena and do my best to create the desired product.

My project taught me the value of patience and multitasking; there were always two or three problems that I was trying to figure out at any given time, and it would get frustrating when one problem would cause another.

My goals themselves are great in terms of the project as a whole, but were too much for one summer given the difficulties inherent in this system and the time lost due to various malfunctions. They included work with PCR reagents and solving the charge issue that were more advanced than I was able to complete during my time here, but some were more easily achievable, such as successfully navigating the LabView software to control the system, and exploring the cause and some possible solutions to the charge issue.

I learned some of the different values that affect the size of the droplets and the array-making process. The largest contributor was the backpressure and flow rate on the liquid, and other smaller contributors were the frequency of the actuation and the power applied to the arm.

In conclusion, while I was unable to complete all of my goals, I provided significant work to the project and with any luck my observations and developments will allow the project to be successful in the future.

Paul Masih Das (Johns Hopkins University)

Mentor: Dr. Jason White

Title: Mass Discrimination Factor in the Analysis of Ablator Materials

At the beginning of the summer, my advisor and I decided that my project would contain two parts. The first part would be to quantify an instrument-dependent variable called the discrimination factor that was taken from the literature due to time constraints in one of my advisor's recent projects. In order to have publishable data, this discrimination factor would need to be quantified for the instrument used in the experiments; therefore this became my first goal. The second part of the experiment would concern the correlation between vacuum-ultraviolet light and the signal from a time-of-flight mass spectrometer. This became my second goal and would help to show that the power of a laser used to ionize molecules for mass spectrometry is independent of the obtained signal.

The first part of the experiment started out relatively smoothly. First, we designed a system that would allow for the heating and injection of binary gases into larger chambers where they could easily be ionized and sent into a mass spectrometer. We then encountered some difficulty in not only monitoring the pressure in the aforementioned system, but also in finding binary gases at the MPL. After futile efforts, we then decided to compromise by substituting liquid chemicals for gaseous ones. Because of this, slight modifications were made to the design of our system. After that, the experiments ran smoothly and the data obtained was comparable to that of the literature. Many attempts were also made to accurately monitor the pressure of the system but none were adequately precise. The main problem was the age of the pressure gauges being used and the inefficiency of the vacuum pump. In the end, a scaling method was used by employing two different pressure gauges. This allowed for determination of the pressure in the system to a degree of accuracy that was sufficient for our experiments.

The second part of the experiment involved the construction and use of a cell containing acetone that would allow for the measurement of the light being using to ionize the gaseous chemicals mentioned previously (ionization is necessary for mass spectrometry). The design and physical creation of the cell began while the first part of the project was still being executed. Its progress was rapid at first but came to a halt after many of the necessary parts could not be found or were too costly. Because of the length of the first part of the project, the cell was never actually completed and put into effect. As of today, more than half of its parts are in place but a few essential ones are still missing.

The incomplete acetone cell that served as the second goal of my project just goes to show the unpredictability of research. Over the course of the summer, my goals changed very little primarily because what I was supposed to do was clearly stated and easy to comprehend. However, the ways in which I was supposed to and did complete the project were very flexible. Over the course of the summer, many compromises and "little fixes" were made to save time and money. In the end, I believe that my experiences at the MPL have been invaluable. I have learned a large amount of information over a wide range of topics and fields that include mass spectrometry, thermogravimetric analysis, laser spectroscopy, vacuum systems, and system design. More importantly, I've experienced firsthand the thinking process involved in research, which is something that can't be learnt from a book. Needless to say, a certain amount of frustration is also involved in this thinking process. And lastly, I've lived the life of a researcher, whether it be waking up early to work a couple of extra hours or sitting and drinking coffee with world-renowned scientists. And for that, I thank the staff at SRI-MPL.

SRI 2011 REU Program Activities.

Regular meetings with the REU students were scheduled to gauge student progress and address any concerns. In addition, several activities were included in the 12 week program to provide a well-rounded REU experience.

1. Seminars

Several opportunities exist for the REU students to attend seminars on the SRI campus. Besides the staff at the Molecular Physics Laboratory (MPL), staff members from across the campus routinely give seminars. In addition, there are invited speakers visiting the campus as well. For example, SRI is the venue for seminars hosted under the Café Scientifique Silicon Valley initiative (<http://www.cafescipa.org>). Below, is a list of seminars attended by the REU students during the summer of 2011.

Date	Time	Seminar Title and Speaker
6-27-2011	11:00-12:00 am	<i>A Cubic Mile of Oil - Realities and Options for Averting the Looming Global Energy Crisis</i> Ripudaman Malhotra, Ph.D Associate director of the Chemical Science and Technology Laboratory SRI International
7-28-2011	10:30-11:30 am	<i>Outer Planet Volatile Abundances</i> Dr. Michael Wong Department of Astronomy University of California at Berkeley
8-9-2011	6:00-7:30 pm	<i>What's to Eat? Deciphering Dietary Advice</i> Marjorie Freedman, PhD Associate Professor at San Jose State University Santa Clara University
8-19-2011	11:00 am - noon	<i>State to State Dynamics Of H + D2</i> Dr. Nathan Bartlett Stanford University

Academic/Industrial Visits, Seminars and Presentations

1. On June 23rd 2011, REU students attended a seminar/presentation given by Richard Lowenthal, founder and CEO of Coulomb Technologies, the leader in electric vehicle charging systems and application services. He shared his company's vision and progress in creating a successful business model to manufacture, distribute, and arrange individual and multi-vehicle use schedules and payment strategies for charging stations for electric vehicles.
2. On July 13th 2011, the REU students attended the poster day event hosted by the Biosciences division at SRI international. The students were able to learn about the

various research areas being pursued in the biosciences division and interacted with several scientists in the division.

3. On July 14th 2011, the REU students toured the CESAR laboratory in the MPL hosted by Dr. Riccardo Melchiorri. CESAR or the Compact Echelle Spectrograph for Aeronomical Research is a spectrometer designed with the goal of providing a high-throughput, high-dispersion, large-passband spectrograph—specifically designed for aeronomers.
4. On July 26th 2011, Dr. Ashot Markosyan invited the REU students to attend a seminar at the Center for Nanoscale Science and Engineering at Stanford University. The seminar titled ‘Medical Applications of Tunable Optofluidic Microlenses’ was presented by Dr. Hans Zappe from the University of Freiburg, Germany.
5. On July 27th 2011, the REU students were given a tour of the Materials Research Laboratories at SRI International. Dr. Jordi Perez hosted the tour. The students were able to learn about research being done in the area of polysilicon production and deposition of silicon films for solar cells. The students also toured one of the laboratories’ pilot facilities for carbon dioxide capture technologies.
6. On July 29th 2011, the REU students toured SRI’s Robotics labs. SRI engineers Drs. Harsha Prahlad and Roy Kornbluh demonstrated various robotics technologies being developed in their laboratories including technologies in the fields of medicine and hydropower technology. The students particularly enjoyed demonstrations of the wall climbing robot.
7. On August 5, REU students toured the SLAC National Accelerator Laboratory. They were accompanied by Dr. Kalogerakis. The public tour, hosted by the laboratory gave the students an opportunity to learn about the research being performed at a national laboratory.

Student Presentations

Around the 11th week of the program, each REU student is required to give a presentation outlining the research they conducted over the summer. MPL’s lab director, the student’s mentor, the other students, and other associated or interested staff attend. Presentations last approximately 20 minutes with an additional 10 minutes reserved for questions and discussion. Below is the presentation schedule for the 2011 REU summer.

Date	Student	Seminar Title
8/10/2011	Paul Masih Das	The Mass Discrimination Factor in the Analysis of Ablator Materials
8/10/2011	Sumana Raj	Studies of O(1D): Processes Relevant to the Ionosphere
8/10/2011	Kendrick Campbell	Studies of Excited Oxygen in the Ionosphere
8/11/2011	Byron Tasseff	Droplet Lipid Bilayers
8/11/2011	Michael Rodriguez	Microdroplet Arrays for Applications in Optical Microfluidics
8/11/2011	Alexander Gvakharia	Metal Nanoparticles for Multiplexed Bioanalysis
8/11/2011	Christina Porter	Frequency Modulated Stimulated Rayleigh Scattering

Ethics Training

A formal mechanism to train the students in the ethics of scientific research was put in place in the summer of 2010. As part of this training, the students were required to take an online course to educate themselves about ethics in a research environment. The online course is available freely at: http://ori.dhhs.gov/education/products/montana_round1/issues.html#intro. The study of the following three sections was mandatory; Section One: Ethical issues in Research, Section Two: Interpersonal Responsibility, and Section Four: Professional Responsibility. At the end of their study of each section, this website provided a test. The students were asked to take the test and furnish copies of their scores to Dr. Sanhita Dixit.

Social Events

Students were invited to attend SRI and Molecular Physics Laboratory events during the course of the REU program. MPL hosted bi-weekly payday meetings for students to learn about current news from the MPL and enjoy bagels/donuts in a congenial atmosphere with other lab scientists. They also attended farewell celebrations for MPL staff, seminar presentations given by prospective postdoctoral research candidates and any group meetings that were of interest or relevant to their research. An SRI “All Hands Meeting” given by company President and CEO, Dr. Curtis R. Carlson, provided the students an opportunity to learn about SRI staff and their research activities.

Students ate together regularly at SRI’s cafeteria and were joined once a week by Dr. Sanhita Dixit.

REU students enjoyed a number of outings over the weekends, which they arranged themselves. San Francisco was a popular destination for sightseeing and attending concerts and San Francisco Giants’ baseball games. Other destinations included Santa Cruz Beach/Boardwalk, the San Mateo County Fair, and local art festivals and farmers’ markets.

Before the REU students left MPL, a farewell celebration was given in their honor.

James R. Peterson Award for Excellence in Undergraduate Research

During its 50th anniversary reunion in 2006, the Molecular Physics Laboratory announced the creation of the James R. Peterson Award for Excellence in Undergraduate Research. This award is given to the summer undergraduate student participating in MPL's NSF-supported Research Experiences for Undergraduates (REU) program that best combines Jim Peterson’s technical excellence and spirit of friendliness and cooperation.

REU student nominations determine the winner of the Peterson Award. The 2011 winner was Michael Rodriguez of California Lutheran University. Previous winners include Anand Oza, Princeton University (2006), Zachary Geballe, University of Michigan (2007), Brad Hartl, University of Wisconsin, LaCrosse, (2008), Aya Eid, Illinois Institute of Technology (2009), and Alejandro Ceballos, Northern Arizona University (2010).