

SRI International

Home Institutions and Research Projects of REU Program Participants — 2000

The SRI REU program assigns each student to work with a staff professional on a separate research project. Typically these projects are a sub-task on a larger research program of the mentor. Some of these projects are independent with the mentor overseeing the students progress on a daily basis. More than half of the projects involve the student working in the laboratory side-by-side with a Ph.D. staff member. Here the data collection task is more collaborative than independent. Since the student projects are each individually supervised, the SRI program can accommodate students with different starting and ending dates.



2000 REU Students & Program Directors
(one student not shown)

2000 REU Projects at SRI

Student from St. John's University, Collegeville, MN.

Mentor: Dr. Gregory Faris

Project: **Spatially Resolved Frequency Domain Measurements of Absorptive and Scattering Coefficients in Absorbing Turbid Media.**

Ultimately, the goal of this project is to obtain noninvasive measurements of the concentration of various compounds in human tissue using light. To this end, we test the viability of time-resolved measurements to provided quantitative analysis of scattering and absorption coefficients in turbid media. We use frequency domain measurements, which are a form of time-resolved measurements. A laser diode source is amplitude modulated at 100 MHz. By measuring the phase shift of the modulated light arriving at points at different distances from the source, one can obtain information on the amount of scattering of the medium. This phase shift is an effective time delay in the arrival of any particular photon, as compared to a non-scattering medium. Each scattering event increases the length of the path a photon takes from source to detector. With combined measurements of amplitude and phase, one can then separately determine the amount of absorption and scatter, through use of the diffusion equation or the radiative transport equation. Currently, measurements are being made in simulated tissue phantoms, using solutions of various effective scattering and absorption coefficients (μ_s and μ_a respectively) which closely match those of skin, muscle, and fat. Eventually, these measurements will be made in two layer phantoms, simulating skin over muscle or fat, to provide a more realistic model of the human body.

Student from Grinnell College, Grinnell, IA.

Mentor: Dr. Philip C. Cosby

Project: **Keck/HIRES and the Study of Earth's Nighttime Terrestrial Atmosphere.**

Using data taken from Keck, the world's largest telescope, we are studying the earth's nightglow and zodiacal light. The Keck's high-resolution echelle spectrograph (HIRES) produces spectra with greater resolution than have previously been achieved. These detailed emission spectra provide new information about the chemical and physical processes in the earth's nighttime terrestrial atmosphere. Specifically, new data regarding the emission lines of O₂ and OH molecules in the 90 km region of the earth's atmosphere are available. This allows us to make new inferences regarding atmospheric temperature and the excited levels of oxygen molecules. New emissions have been discovered in regions where it had previously been perceived as background noise. Since the atmosphere fluctuates over several time periods such as days, seasons and years we are currently examining the data in greater detail in the hopes of finding a correlation between the collected spectra and environmental factors that affect it. The overall objective of this project is to produce a general model of the earth's nightglow emissions in order to gain new information regarding mesospheric processes.

Student from Reed College, Portland, OR.

Mentor: Dr. Laura T. Iraci

Project: **Solubility of Methanol in Sulfuric Acid under Atmospheric Conditions**

Recent measurements taken in the upper troposphere/lower stratosphere (UT/LS — approximately 10-16 km) indicate a significant amount of methanol in this region. Estimates of the global budget of methanol (i.e., its major sources and sinks) have also been attempted recently, but do not balance; there are not enough known sinks of this gas to compensate for production. Further recent studies show that sulfate aerosols in the UT/LS contain unidentified organic compounds. Our research, therefore, attempts to determine whether the solvation of methanol into sulfuric acid constitutes a significant sink. To achieve this we calculate the solubility of gaseous methanol under pressures and temperatures similar to those of the UT/LS. The calculation is derived from the uptake of methanol into a reservoir of cold sulfuric acid. We measure the uptake by observing the difference in mass spectrometer signal between the baseline and exposure conditions. Our data indicate that solubility in sulfate aerosols will not provide a significant sink of methanol in the atmosphere.

Student from Macalester College, St. Paul, MN.

Mentor: Dr. Gregory W. Faris

Project: **Stimulated Rayleigh and Brillouin Scattering in Supercritical Fluids.**

Stimulated scattering is a nonlinear process that can be used to better understand the physical properties of fluids. Rayleigh scattering, the scattering of light from density fluctuations caused by non-propagating entropy waves, provides information on thermal properties. Brillouin scattering, the scattering of light from density fluctuations caused by acoustic waves, provides information on elastic or compressional properties. In this experiment, stimulated Rayleigh and Brillouin scattering were induced by overlapping the beam of a high power, injection-seeded Nd:YAG laser (pump laser) with that of a weaker tunable diode laser (probe laser) at approximately 1064 nm. The probe laser frequency was modified until scattering was observed and a spectrum was collected. The widths and shifts of the Rayleigh and Brillouin peaks in a measured spectrum were the parameters used to determine the thermal and compressional properties of near critical and supercritical hexane.

Student from Oberlin College, Oberlin, OH.

Mentor: Dr. Philip C. Cosby

Project: **Electron-Impact Dissociation of Small Molecules**

The interaction of electrons with molecules is an important process in physics. This project involves dissociating molecules by electron-impact and examining the fragments. The two basic questions we look at are: (1) What is the cross-section (the number of dissociations that will take place for a certain electron energy) and (2) what are the dissociation products? A beam of electrons ionizes molecules in a gas to give us charged ions, which are accelerated into a 5 keV beam. We then mass-select the desired molecular ions by bending them through a magnet, and then send them through a charge transfer cell giving us a fast beam of neutral molecules that is collimated by a slit. This neutral beam is crossed by a second electron beam that causes some of the molecules to dissociate into fragments that are detected on a time and position sensitive detector. The dissociation process is measured at electron energies between the dissociation threshold (around 20 eV) to around 200 eV. We are currently looking at CF, CF₂, and CF₃.

Student from Reed College, Portland, OR.

Mentors: Dr. Harald Oser and Dr. Michael J. Coggiola

Project: **Trace Gas Analysis by Resonantly Enhanced Multiphoton Ionization**

In this project, a REMPI-based instrument measures low concentrations of selected compounds in a gas sample. The instrument uses supersonic-cooled, Resonantly Enhanced Multiphoton Ionization (REMPI) in conjunction with a Time of Flight Mass Spectrometer (ToF-MS). This provides high sensitivity (detection down to 10 parts per trillion), high selectivity (ability to distinguish between isomers), and the ability to measure samples in real time without pre-concentration or pre-treatment. Current work is focused on measuring wavelength dependent spectra of potential hazardous air pollutants (HAPs). We are also investigating the possibility of using REMPI in breath analysis to diagnose diseases such as lung cancer and liver cirrhosis.

Student from Bowdoin College, Brunswick, ME.

Mentors: Dr. Konstantinos S. Kalogerakis, and Dr. Richard A. Copeland

Project: **Laboratory Studies of Processes Important in Airglow**

"Airglow" is the term used for describing the emission that occurs naturally in the Earth's atmosphere at an altitude of about 90 km and a temperature range of about 150-250 K. Such emission has also been observed in other planetary atmospheres such as Mars or Venus. One component of the airglow is emission from excited electronic states of molecular oxygen. On this project, we examine the spectroscopic and collisional energy transfer processes in these states in the laboratory. We use a two laser approach where a pump laser excites the O₂ molecules to a specific rotational and vibrational level of the A state, and a probe laser detects the electronic states populated following collisions. The ion signal is recorded as a function of pump-probe delay. From the temporal evolution of the ion signal, we extract rate constants for the collisional deactivation. The temperature dependence and colliders important in the atmosphere (e.g. O₂, N₂, and CO₂) are studied.