REU Research Projects

The SRI REU program assigns each student to work with a staff scientist on a separate research project. Typically these projects are a sub-task in a larger research program of the mentor. Some of these projects are independent with the mentor overseeing the students progress on a daily basis. The majority of the projects are experimental, with the student working in the laboratory side-by-side with a Ph.D. staff member. Since the student projects are each individually supervised, the SRI program can accommodate students with different starting and ending dates.

Molecular Physics Lab REU Students 2001

REU Participants (from left to right): Austin Brown, Quinn Spadola, Justin Schneiderman, Wannasiri Lapcharoensap, Benjamin Blehm, Shahla Ali, Megan Hryndza, and Gregory Grist

Shahla Ali
Student from University of California, Irvine (CA)
Mentor: Dr. David Huestis
Project: **"Velocity Distribution of Interplanetary Dust derived from Astronomical Sky Spectra"**

The W. M. Keck telescope on Mauna Kea routinely generates what are called sky spectra, which are emission spectra of the foreground terrestrial nightglow that the telescope must peer through to view its stellar targets. The nightglow is generated as a result of the absorption of solar energy during the day, which is released *via* chemical reactions at night. We have recently discovered that these spectra represent a major advance over the standard optical techniques used by those who carry out nightglow research, and in collaboration with the astronomers, we are detecting the presence of many molecular and atomic emissions not previously seen. These nightglow spectra also include a weak contribution from zodiacal light - sunlight scattered from interplanetary dust particles. Since the solar spectrum is replete with Frauenhofer lines, these absorption features complicate the analysis of the nightglow emissions, especially in the blue regions of the spectrum. This project studied Frauenhofer lines appearing the sky spectra, using their lineshapes and intensities to characterize the zodiacal light and the dust particles themselves. Once the zodical light contribution is understood, it can be removed from the sky spectra to allow molecular emissions (mainly from oxygen) in the terrestrial nightglow to be analyzed.

Benjamin Blehm
Student from Grinnell College (IA)
Mentors: Drs. Gregory Faris and Konstantinos Kalogerakis
Project: "Stimulated Scattering in Supercritical Hexane"

When intense light from a pulsed laser interacts with matter, the light can elicit a nonlinear optical response. One type of nonlinear optical response is stimulated scattering, in which the intense light causes a tremendous increase in the amount of scattered light from atoms or molecules. We use stimulated scattering to measure inherent properties of matter including chemical properties (using stimulated Raman scattering from vibrational and rotational modes), elastic properties (using stimulated Brillouin scattering from acoustic modes) and thermal properties (using stimulated Rayleigh scattering from thermal modes). We performed the first stimulated scattering measurements in supercritical hexane. In future work, we will study transient effects and near-critical fluctuations.

Austin Brown
Student from Harvey Mudd College (CA)
Mentor: Dr. David Crosley
Project: "Rotational Energy Transfer in Gaseous NO"

Spatially-resolved laser measurements of intermediate species in premixed, laminar, low pressure, hydrocarbon-air flames are used to test our knowledge of the time-dependent combustion chemistry, by comparisons to model calculations. We investigated processes involving A) the formation and destruction of pollutant NO, and B) the production of NO in methane flames, using calibrated laser induced fluorescence (LIF). Flame temperatures were determined by LIF of OH. These experiments involved laser spectroscopy, operation of the low pressure burner and computerized data system, CCD camera imaging, and some computer chemistry modeling of the results, using proven techniques.

Gregory Grist
Student from San Francisco State University (CA)
Mentor: Dr. Harald Oser
Project: "Detection of Hazardous Air Pollutants by Jet REMPI"

This project used a laboratory prototype instrument based on laser-mass-spectrometry to measure trace levels of Hazardous Air Pollutants (HAPs). This real-time continuous emission monitor

(CEM) combines a pulsed gas jet with resonance enhanced multi-photon ionization (REMPI) and time-of-flight mass spectrometry (TOFMS). We conducted a limited field study by collecting ambient air samples at a variety of urban and industrial sites in the San Francisco Bay Area. In an initial step, these samples were analyzed using traditional gas chromatography/mass spectrometry (GC/MS) to determine composition and concentration levels. Afterwards, these samples were analyzed with our existing Jet-REMPI instrument. This was an opportunity to learn sampling techniques and conventional chemical analysis based on GC/MS. It also included work with state-of-the-art laser technology, time-of-flight mass spectrometers, and high-speed data acquisition electronics.

Megan Hryndza
Student from the University of Illinois, Urbana (IL)
Mentor: Dr. Gregory Faris
Project: "Upconverting Chelates for Cancer Detection and Diagnosis"
We are investigating the use of light for medical diagnostics. This work uses the basic physics of light interaction with matter to extract meaningful physiological information. Current research includes photon density waves and upconverting chelates. Upconverting chelates are an unusual type of molecule we have recently discovered. These materials "upconvert" infrared radiation to visible radiation. That is the emitted photons have higher energy than the absorbed photons. When these molecules are attached to biological probe molecules such as antibodies or DNA probes, very sensitive medical tests may be performed. The present project characterized the chemical synthesis and optical characteristices of a number of upconverting chelates that may be used for cancer detection.

Wannasiri Lapcharoensap
Student from Wellesley College (MA)
Mentor: Dr. Richard Copeland
Project: "Studies of Collisional Removal of O_2 ($^5\Pi_g$,v=0)"
The upper atmosphere of the earth "glows" due to chemical reactions and physical processes occurring from 70 to 200 km above the surface. The northern lights are an extreme example of a type of airglow. In addition to terrestrial observations, spacecraft have measured similar glows above the other planets and their moons. In our laboratory, we study the collisional processes important in airglow phenomena. Tunable pulsed dye lasers are used to excite and monitor the molecules important in the atmosphere. Experiments are underway on oxygen excited electronic states. The temperature dependence of the energy transfer collisions is measured since the emitting layer in the earth's atmosphere can be below 200 K. This project characterized the collisional removal of the ground vibrational level in the O_2 $^5\Pi_g$ state, which is formed by recombination of atomic oxygen atoms in the upper atmosphere.

Justin Schneiderman
Student from Worcester Polytechnic Institute (MA)
Mentor: Dr. Gregory Smith
Project: "LIF Study of C_2 in Low Pressure Flames: Quenching and Concentration"
Spatially-resolved laser measurements of intermediate species in premixed, laminar, low pressure, hydrocarbon-air flames are used to test our knowledge of the time-dependent

combustion chemistry, by comparisons to model calculations. We are currently investigating processes involving the production of chemiluminescent OH* and CH* light emissions from flames to provide interpretation of diagnostics used in space shuttle experiments. Interpreting visible flame chemiluminescence requires both production and loss rate constants, and the loss rates can be determined from quenching lifetimes of LIF signals. The current project involved making these measurements for C_2*, which is a precursor to CH*. We determined the quenching decay rate of excited C_2* and the ground state distribution and amount in low pressure methane, ethane, and ethylene flames using laser induced fluorescence in the C_2 (d-a)(2,0) Swan band at 438 nm. These experiments involved laser spectroscopy, operation of the low pressure burner and computerized data system, CCD camera imaging, and some computer chemistry modeling of the results, using proven techniques

Quinn Spadola
Student from Mary Washington College (VA)
Mentor: Dr. Jochen Marschall
Project: "Oxygen and Heat Flux Sensors"

The heat flux delivered to a surface is an important quantity that can influence the design and performance many high-temperature systems (e.g., gas turbines, fire barriers, rocket nozzles, spacecraft heat-shields). Heat flux can be monitored with a gauge consisting of a thin ceramic layer sandwiched between two thin-film platinum resistance thermometers. The heat flux passing through the gauge is related to the temperature difference between faces and the thermal conductivity of the ceramic layer; $q = -k\, dT/dx$. This project will explore methods to characterize the performance of these heat flux gauges exposed to periodic laser heating. By varying the laser power and pulse frequency, the dynamic response of the gauges can be captured. Thermal models can then be used extract the thermophysical properties of the ceramic layer and to develop a calibration procedure for individual gauges. The current project involved characterizing the response of the sensor to atomic oxygen and ozone impacting its surface.