

## Molecular Physics Lab REU Students 2002



Top row: Michael Herring, David Nash, Elliott Barcikowski, and Seth Koterba  
Bottom row: Sarah Smith, Kelly Cone, Kendra Rand, Emily Spangler (Dreyfus), and Virginia Hafer.

### **Elliott Barcikowski**

**Student from the University of Montana (MT)**

Mentors: Drs. Tom Slanger, Kostas Kalogerakis, and Richard Copeland

Project: **"Laboratory Studies of Processes Important in the Oxygen Airglow"**

Experiments were performed to study the collisional processes occurring following ozone photodissociation by a pulsed laser. The laser spectroscopic techniques resonance-enhanced multiphoton ionization (REMPI) and laser-induced fluorescence (LIF) were used to study the products. These products are important in the glows observed in the upper atmosphere. These glows occur 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, spacecrafts have measured similar glows above the other planets and their moons.

**Kelly V. Cone**

**Student from Cal Poly, San Luis Obispo (CA)**

Mentors: Dr. Richard Copeland and Dr. Eloy Wouters

Project: **"Vibrational Energy Transfer Measurements on the Hydroxyl Radical"**

Vibrationally excited hydroxyl radicals are generated in the coldest region of the Earth's upper atmosphere by the reaction of atomic hydrogen and ozone. The infrared and visible emission from the OH radical is currently being measured by the NASA TIMED satellite. To convert the emission intensities to the physical condition of the atmosphere at any given time, laboratory measurements are required to fix the input parameters of the atmospheric models. We used a two-laser technique to investigate the collisional energy transfer between the vibrationally excited OH radicals and oxygen. An infrared laser light pulse excites OH radicals to a higher vibrational level. A short time later, an ultraviolet laser pulse probes the amount of OH that is left in the vibrational level. By varying the time between the two laser pulses and the color of the pulses we followed the OH molecules as they relax from vibrational level to vibrational level transferring much of their initial energy to the oxygen molecules. The studies are performed at low temperature (~225 K) to simulate the conditions of the Earth's upper atmosphere.

**Virginia Hafer**

**Student from Wellesley College (MA)**

Mentor: Dr. Harald Oser

Project: **"Analysis of Aqueous Samples using Laser Ionization Mass Spectroscopy"**

This project used a laboratory prototype instrument based on laser-mass-spectrometry to measure trace levels of Hazardous Air Pollutants (HAPs) in aqueous samples. Our real-time continuous emission monitor (CEM) combines a membrane based water sampler with resonance enhanced multi-photon ionization (REMPI) and time-of-flight mass spectrometry (TOFMS). In this proof of principle study a novel membrane based water sampler was combined with our REMPI mass spectrometry technology. During the project we gathered data on limits of detection, and selectivity for a variety of target compounds in aqueous samples. This data will be used as input for proposals as well as published in a scientific journal.

**Michael E. Herring**

**Student from Catholic University (DC)**

Mentor: Dr. Gregory Faris

Project: **"Spectroscopy of Upconverting Chelates"**

Diagnostic techniques that incorporate molecular-specific information about genes, proteins, and pathogens will be gaining increasing importance in the future diagnosis and treatment of disease. One way to do molecular diagnostics is to use a probe, such as an antibody, that rapidly binds to a specific target. A label, or reporter, is bound to the probe to detect the binding of the probe to the target. The eventual goal of this project is to demonstrate the potential of a new kind of reporter, upconverting chelates. These chelates are unusual because they convert lower energy

light to higher energy light, by absorbing two photons, then emitting a single, higher energy photon. The advantages of choosing upconverting chelates as reporters include good tissue penetration, low phototoxicity, photochemical stability, and little autofluorescent background (as upconversion is rather rare in nature). We mainly worked with compounds of neodymium chelated in either ethylenediaminetetraacetic acid (EDTA) or pyridinedicarboxylic acid (DPA). We used two Nd:YAG-pumped tunable dye lasers to excite the chelate samples, and studied one-color (both lasers at ~582nm) and two-color upconversion (lasers at ~589 nm and ~800 nm).

**Seth Koterba**

**Student from Concordia College (MN)**

Mentor: Drs. Philip Cosby, David Huestis, and Tom Slanger

Project: **"Analysis of Emission Spectra from the Venus Atmosphere Obtained by Ground-Based Telescopes"**

The atmosphere of Venus is composed predominantly of carbon dioxide, but trace quantities of excited oxygen atoms and molecules can be produced by chemical reactions. This project was to search for the signature emissions of these excited species in the echelle spectra taken of the Venus nightside atmosphere using the 3.5 m telescope at the Apache Point Observatory. The reduction of these spectra was a challenge because the echelle spectrograph provides high resolution spectral coverage of the entire 350 - 1000 nm optical region dispersed in approximately 128 overlapping orders. One result of the project was the development of a unique method to accurately perform both the flat-fielding and the intensity calibration of the spectra using the standard star observations. This allowed a systematic reduction of the spectral data to plots of emission intensity versus wavelength, identification of new atomic and molecular oxygen emissions, and comparisons to identify temporal variations in the emissions with the objective of understanding the physical and chemical processes occurring in Venus' upper atmosphere.

**David Nash**

**Student from Santa Clara University (CA)**

Mentor: Dr. Greg Smith

Project: **"Jovian Atmospheric Photochemistry"**

The outer giant gas planets like Jupiter have hydrogen atmospheres with some methane. After methane photolysis, additional chemistry forms larger species that condense out, and intermediates that are measured by telescope and space probes. We determined quantitatively which key reactions and photolysis steps control the concentrations of various species, by performing a sensitivity analysis of a model of Jupiter's atmosphere. This procedure identified reactions needing improved rate constants, and observations that test the photochemical model.

**Kendra Rand**

**Student from Carthage College (WI)**

Mentor: Dr. Gregory Faris

Project: **"Breast Cancer Detection using Optical Vascular Function Imaging"**

To sustain their growth, tumors create their own blood vessels. These vessels have some unusual properties that result in abnormal levels of hemoglobin concentration and oxygenation in response to the inhalation of oxygen and carbogen. When near infrared light passes through

tissue, changes in the hemoglobin concentration are manifested as changes in the intensity of the transmitted light. This project investigated these abnormal intensity changes with the aim of using them as a method for detecting breast cancer. Preliminary work involved an immersion-based frequency domain approach to measuring the scattering and absorption properties of tissue. A multiple-wavelength imaging system was also constructed for observing the changes in intensity qualitatively. This work is part of a two-year project that involves the imaging of tumors in animals using these techniques. The goal of this project is to determine the ability of these techniques for detecting and diagnosing breast cancer.

**Sarah E. Smith**

**Student from Truman State University (MO)**

Mentors: Dr. Gregory Faris

Project: "**Optical Microfluidics**"

Microfluidics is a technique in which fluid samples are moved, mixed, and otherwise manipulated on a substrate. The samples are small, which allows a large number of samples to be processed relatively quickly (high throughput) without consuming a large sample volume. The majority of microfluidics systems in use currently operate by using electrophoretic or electroosmotic forces to move the samples on the substrate. These systems require involved circuitry to be incorporated into the substrate, which can be costly if the substrate is to be disposable. Also, these systems offer little flexibility in reconfiguring assays, and are inefficient in sample use. However, these drawbacks can be overcome using the method of optical microfluidics, the focus of our project. Optical microfluidics uses the radiation pressure from a highly focused laser beam to move small droplets. We developed a series of optics that allowed the laser to be moved smoothly and accurately without moving the substrate. We also worked on a method for creating and dispensing fluid samples. Motion of a wide range of droplet sizes and high speed motion were achieved.