Research Statement

Research has been an integral part of my education as an undergraduate, and my experiences have contributed greatly to my decision to pursue graduate study. I began my research experience in my second year at the University of Michigan. As part of the Undergraduate Research Opportunities Program, I worked with Dr. Diane Paulson analyzing the spectrum of a flare on Barnard's Star. Barnard's star is a well-studied nearby (d=1.8pc) M dwarf, and is though to be extremely old due to its slow rotation rate, low x-ray luminosity, and lack of Balmer lines during quiescence. My work focused on spectra taken at Mc Donald observatory during observations for the McDonald Observatory Planet Search program. These observations serendipitously detected a flare on Barnard's star, which was the focus of my research.

Although I began the project with no prior experience, I quickly learned the basics of IDL programming and how to use the Image Reduction and Analysis Facility (IRAF) software package to identify the spectral signatures of elements in the atmosphere of Barnard's Star. I recorded all flare-related emission lines, including unexpected lines from aluminum and silicon. My work was primarily independent, but I received frequent guidance from Dr. Paulson. My measurements formed the foundation for more extensive study of the flare performed by Dr. Paulson and our collaborators. We estimate the temperature in the flaring region to be >8000K, and an electron density of $\sim 10^{14}$ cm^{-3}. We recently submitted a paper to Publications of the Astronomical Society of the Pacific[1] that summarizes our results.

Following my sophomore year, I participated in a Research Experience for Undergraduates (REU) program at the Harvard/Smithsonian Center for Astrophysics. I spent the summer with Dr. S. Thomas Megeath developing a new method for mapping the density of molecular clouds in regions with diffuse infrared emission using the 5.8 and 8.0 micron sensitivity bands of the InfraRed Array Camera (IRAC) on the Spitzer space telescope. We modeled how the observed surface brightness and the ratio of the surface brightness vary with foreground extinction. By comparing with the result of the model, one can estimate extinction. As a test case, we applied the method to several well-defined filaments in the Orion Molecular Cloud 2/3 (OMC 2/3) region. The observed absorption in the OMC 2/3 filaments was also compared to that predicted from a model of an isothermal cylinder to arrive at an independent estimate of column density.

Once again, much of my work was independent, but I met with Dr. Megeath several times every week to discuss results and where to go next. One significant result of my work was the discovery that infrared light that is attenuated in molecular clouds appears more "blue" than normal in Spitzer measurements. This is explained by the large silicate absorption feature in the 8.0 micron sensitivity band. By the end of the summer I had experience programming in IDL, analyzing data, writing a scientific paper, and presenting the results to experts in the field. I presented a poster with our results at the American Astronomical Society conference in January 2005[2].

I spent the past summer in Houston, Texas at the Lunar and Planetary Institute working with Dr. Walter Kiefer determining the fill thickness of Quasi-Circular Depression (QCDs) on Mars. QCDs are invisible, ancient impact features detected by the Mars Orbital Laser Altimeter (MOLA). The amount of debris filling QCDs on Mars can give clues to the planet's most ancient history, including the possibility of a shallow sea in the northern hemisphere. I used the GRIDVIEW program developed by Dr. Herb Frey and Dr. Jim Roark to analyze MOLA data and record the diameters and depths of QCDs. For each basin, multiple estimates of rim height were made based on the least degraded portions of rim. Depths were measured as the difference in elevation between the average rim height and the lowest (non-crater) point within 100km from the QCD center. This work was done almost entirely independently, with occasional guidance and input from Dr. Kiefer.

Our results show that basins in the northern hemisphere of Mars are more filled than their southern counterparts. Results also suggest that the impact that formed the Hellas basin played a significant role in filling surrounding ancient craters. Dr. Kiefer will be using the data I gathered to make gravitational models of the ancient impact basins, which may help determine the type of material filling the basins, and address the dichotomy between the northern and southern hemispheres. I will be presenting a poster of our results at the 2006 Lunar and Planetary Science Conference.

I am currently working with Dr. J. Hunter Waite and a team of chemists and engineers on developing a 2-Dimensional Gas Chromatograph/Mass Spectrometer (2DGC/MS) for the Mars Science Laboratory rovers. The mass spectrometer on Viking 1 and 2 detected no organic molecules on the Martian surface, but low levels of organics are expected due to comets and meteorites. The main goal of the 2DGC/MS is to detect traces of organic molecules on Mars and better understand the planet's biogeochemistry. My role in the project is to work with Dr. Waite to develop a pattern recognition routine that will allow automated identification of organic compounds. To date I have focused on mass deconvolution and identifying peaks in the mass spectra. I will soon begin adapting an existing program to accurately simulate runs of the prototype instrument, incorporating the thermal modulation between GC columns and producing a 2-dimensional data product similar to that produced in an actual run. In addition, we will soon begin building a library of data from known compounds to identify common patterns that can be used in a pattern recognition algorithm.

1. Paulson, D.B., Allred, J., **Anderson, R.B.**, Cochran, W.D., Hawley, S.L. & Yelda, S. Optical Spectroscopy of a Flare on Barnard's Star, 2005. Submitted to PASP.
2. **Anderson, R.B.**, Megeath, S.T., Meyers, P.C. Mapping Molecular Clouds Using Spitzer's InfraRed Array Camera, American Astronomical Society Meeting 205, #140.02, 12/2004.