2010 REU Research Projects

Please rank these projects by advisor name in the order of your preference (1 = highest interest) on the back of your application.

1 Prof. Gordon Stacey

Star Formation

The Stacey research group is focused on the study of star formation in galaxies from the local Universe to the very distant Universe (redshifts of 2 - -looking back to within 2.6 billion years of the Big-Bang). Our primary probes are the mid-J rotational lines of CO and the bright far-IR fine structure lines such as the 158 um [CII] line. These lines cool molecular clouds in galaxies and enable their collapse to form stars.

We build state of the art spectrometers to detect these lines and use our spectrometers on the world's largest submillimeter telescopes such as the 12 meter Caltech Submillimeter Observatory on Mauna Kea. This means that in addition to studying the astrophysics of distant galaxies we build and improve our spectrometers in the lab. Building such spectrometers involves low temperature physics (our detectors operate as low as 60 milli-Kelvins), optics, electronics, semi-conductor and super-conductor physics, mechanical engineering, and software development. REU students are involved in the on going research in the lab and can pick a particular subproject of interest. In the past, students have built cryogenic Fabry-Perot interferometers, electronic boxes that control Helium-3 refrigerators, designed optics, created data reduction software, as well as participated in the science of distant galaxies.

We are also participating in complementary extragalactic science with the European Space Agencies Hershel Space Telescope, a 3.5 m submillimeter telescope to be launched in early 2009. There will be science and software opportunities linked with the telescope as well.

2 Prof. James Houck / IR Group

The Spitzer Space Telescope: the Last Element in the "Great Observatory Program."

Cornell designed and built the Infrared Spectrograph, IRS, for Spitzer. This coming summer the areas of interest are: Stellar Birth and Death in Nearby Galaxies, Planetary Nebulae, Dwarf Galaxies and HII Regions in the Galaxy. The successful applicant will work on one of the three programs. He/she can select their own area of interest, learn to reduce data from the IRS and participate in preparing the manuscript for publication.

3 Dr. Kevin Covey

Studying Stellar Variability at Optical to Mid-infrared Wavelengths

Variability is a defining observational characteristic of Young Stellar Objects (YSOs). At optical wavelengths, periodic optical variability is typically attributed to starspots rotating across the star's surface, and aperiodic variations are explained by chaotic fluctuations in the YSO's mass accretion rate. YSO variability at longer wavelengths is not nearly as well understood. A new Spitzer Warm Mission program (YSOVAR; http://ysovar.ipac.caltech.edu/) is currently monitoring young stars in 11 star forming regions at mid-infrared wavelengths; an extensive campaign of coordinated observations being conducted by various ground and space-based observatories, at wavelengths ranging from the X-rays into the radio. Students joining this project will use this large observational database to identify variable young stars, classify their variability as periodic or non-periodic in nature, and analyze their full multi-wavelength light curves to interpret the astrophysical mechanisms driving the variability. This project will be well suited to students interested in astronomical observations at any (or many!) wavelengths, survey science, computational methods and the physics of star and planet formation.

4 Prof. Saul Teukolsky

Computer Visualization of Black Holes from Supercomputer Simulations

The work of the undergraduate in this project will involve numerical computations, color graphics and video animation. The project will focus on forefront problems in Theoretical Astrophysics and General Relativity, such as black holes, gravitational waves, relativistic neutron stars, and fluid flows. In particular, the undergraduate will build graphics software for the visualization of binary black holes in orbit about each other. The research group at Cornell is involved in calculating the inspiral and coalescence of two black holes in such a system as they lose energy by emitting gravitational waves. Such events are likely to be detectable by the LIGO gravitational wave detector now beginning to take data. The undergraduate will develop software to help study the output of these large-scale computer calculations.

Student Qualifications

Candidates for this position should be majoring in astronomy, physics or engineering physics and have a strong background in fundamental physics and mathematics. In addition, experience with computing is highly desirable. Students should be interested in continuing this research during the remainder of their undergraduate careers after the conclusion of the summer.

5 Prof. Joseph Veverka

Size and Shape of Comet Nuclei from Spacecraft Imaging

NASA’s Deep Impact spacecraft will carry out a close flyby of Comet Hartley 2 in November 2010. In preparation for the encounter, we will be automating and refining techniques to quickly determine the size, shape and volume of a comet nucleus from imaging data. We will test these new procedures on previously acquired images of Wild 2 (by Stardust) and Tempel 1 (by Deep Impact).

6 Prof. Terry Herter

Science Planning for SOFIA

Our team at Cornell has constructed a astronomy instrument, FORCAST, for use with SOFIA (the Stratospheric Observatory For Infrared Astronomy). SOFIA, a modified Boeing 747SP airplane housing a 2.5 meter telescope, is scheduled to begin its first science flights in summer/fall 2010. FORCAST (Faint Object infraRed Camera for the SOFIA Telescope) attaches to this telescope and images at different wavelengths (colors) in the infrared part of the spectrum. FORCAST will be the first instrument to fly on SOFIA. We are looking for help in science planning for multi-color infrared imaging with FORCAST. Science targets include the center of our Galaxy, star forming regions (such as the Orion Nebula), and debris disks around stars (such as Vega and Fomahaut). In addition, this work there is likely involvement in helping to test FORCAST and participate in some of the activities at NASA Dryden (outside Palmdale, CA).

7 Prof. Joseph Burns

Observations of Saturn's Rings by the Cassini Spacecraft

Our project seeks to understand the morphology and particle properties of Saturn's rings. We are members of the imaging team on the Cassini mission, which has been orbiting Saturn since 2004. We need help in processing these images to find their geometry and position, as well as to locate features in them. Since this involves use of image-processing software, we seek individuals who are comfortable with computers. Prior training is not, however, required.

8 Dr. Robin Garrod

Complex Molecules in Diverse Interstellar Environments

Complex, saturated organic molecules (of up to 12 atoms) have been detected in star-forming regions, and some of these molecules are of biological significance. Such molecules are typically detected deep within the warm (>100 K) envelopes of high-mass protostars, and are thought to be formed within ices on the surfaces of interstellar dust grains, before evaporating into the gas phase. Recently, highly complex molecules have also been detected in a range of other interstellar environments, including low-mass star-forming regions, shocked clumps in protostellar outflows, and molecular clouds near to the Galactic Center. However, while the physical conditions in these regions vary, the detected abundances of complex species are remarkably similar, indicating a common dust-grain ice composition. In this project, the student will apply a simple computational chemical/physical model to a selection of interstellar environments, to reproduce gas-phase and dust-grain chemical abundances, and to explain the similarities and differences in complex molecule formation between each site. The results will allow us to better understand the formation of biologically significant molecules in space, and to make predictions for the upcoming ALMA and JWST telescopes. This project does not require a chemistry background - only an interest in astrochemistry.

9 Prof. James Bell

Geology of the Mars Exploration Rover Spirit Landing Site

The Mars Exploration Rover Spirit has been driving within Gusev Crater, Mars for almost six years. The majority of Spirit's exploration has been near an interesting feature called Home Plate, which is a plateau of layered rocks that we interpret as a hydrovolcanic feature (the result of an explosive volcanic event where magma mixed with water or ice). One of our goals is to understand how widespread this type of hydrovolcanic activity may have been in and around Gusev Crater. We are looking for an undergraduate student to help us perform a survey of geomorphic features seen in high-resolution images from the HiRISE and CTX cameras onboard the Mars Reconnaissance Orbiter (MRO) This project will involve creating maps from imaging datasets, using the geologic mapping software ArcGIS to show the distribution of features, and interpreting which features may be related to volcanic and/or ice related processes. This work will require a familiarity with UNIX, Mac and PC computing environments. While an interest in Martian geology is a must, no prior background in geology is required.

10 Prof. Steve Squyres and Dr. Wesley Watters Farfan

Survey and Analysis of Impact Crater Planforms

One of our projects concerns measuring the distribution of impact crater shapes to learn something new about the cratering process, as well as how crater formation is influenced by properties of the target. For this purpose, we are building a database of fresh Martian impact craters in high-resolution images from the HiRISE camera onboard the Mars Reconnaissance Orbiter (MRO). Measurements derived from these images (e.g., crater and ejecta outlines) are used to calculate a large number of shape parameters. The distributions of these quantities are then compared against the distributions generated by numerical models of crater formation. We also use these data to identify differences between crater shapes formed in different geological targets, as well as transitions between styles of crater formation that occur in specific size ranges. Another goal is to recognize patterns in the global atmospheric circulation which can be mapped from subtle features of crater shape formed by surface winds.

We'd like an undergraduate researcher to help us with (a) searching for fresh craters and craters with special characteristics in the [huge numbers of] new HiRISE images; (b) characterizing impact craters and the surrounding target materials (e.g., characterizing layer patterns on crater walls, fracture patterns in surrounding target materials, the amount of wall failure/slumping; tracing rim outlines, tracing ejecta margins, and measuring fracture orientations). There will be some opportunities to create and refine data-collection tools as well as some data analysis using Python (NumPy) and or Matlab.