RESEARCH PROGRAM

Science and Engineering Abstracts for Grants Awarded in June 2012

California Association for Research in Astronomy
Peter Wizinowich
$1,500,000
In 2004, the Keck II Laser Guide Star Adaptive Optics (LGS AO) system was the first LGS system on a large telescope. The primary goal of this project is to improve the scientific performance of the AO system by procuring and implementing a next generation laser. Secondary goals include: (1) operational improvements (such as laser reliability and efficiency) associated with replacing an aging experimental laser with a commercial product; and (2) continued development of the W. M. Keck Observatory's (WMKO) next generation AO system. The existing AO system uses a 13 W pulsed dye laser to excite the sodium atoms in the mesosphere. The level of AO correction is limited by the laser power and especially by the low coupling efficiency of a pulsed laser to the sodium atoms. Continuous wave lasers have been demonstrated to have about 10 times the coupling efficiency of the dye laser. The WMKO team has been collaborating with the European Southern Observatory and a consortium of U.S. observatories to develop a 20 W commercial continuous wave laser. The resultant laser has been demonstrated in the lab by a consortium of two laser vendors, TOPTICA and MPBC, and has completed its final design. This next generation laser, meeting all specifications, is now available and will sustain the Observatory's leadership in LGS AO science for years to come.

Northwestern University
Neil Kelleher
$1,000,000
Protein complexes are cellular machines that manage and perform most functions in our cells and in all living organisms. Scientists continue to struggle to understand their composition, their structure and how they can malfunction. Because the most revealing and accurate approach—examining native complexes as entire units—has seemed virtually impossible, most analyses have used mass spectrometry of protein fragments, which may lead to partial or misleading results. A team from Northwestern University, in collaboration with Thermo Fisher Scientific, plans to overcome this major barrier in disease research by developing a new kind of mass spectrometer that combines the advantages of Time-of-Flight (TOF) and Fourier Transform (FT) analyzers. This instrument will be used to separate an intact protein complex from a mixture and then detect it directly or activate to release its subunits. The instrument will then detect the intact masses of subunits and the fragmentation products that result from their stepwise disassembly. To this platform, they will couple new separation strategies and software, followed by application of the combined system to mitochondrial complexes isolated from models of aging and kidney cancer. This integrated workflow will constitute a major advance in protein mass

spectrometry, accelerate the understanding of disease at a molecular level, and address a key challenge of this century: to define the human proteome.

University of California, Berkeley
Geoff Marcy
$1,000,000

The Kepler Mission has demonstrated the existence of large numbers of Earth-size planets and smaller, but most of them reside over 300 parsecs away, making follow-up study of those planetary systems difficult at best. A team at Berkeley proposes to discover Earth-size planets around nearby stars (within 25 parsecs) to permit imaging and spectroscopy of those nearest planetary systems, and to allow measurements of their outer planets, zodiacal dust, and host star properties. They will build a novel "Habitable Worlds Spectrometer" designed specifically to detect the tiny Doppler shifts of nearby stars that can reveal the Earth-size planets orbiting them. The spectrometer will be deployed at the new 2.4-meter APF Telescope at Lick Observatory, for which the team has access 45% of nights. This spectrometer will achieve a Doppler precision of 0.3 m/s, which is 5x better than the spectrometer designed 10 years ago that is currently being commissioned on the APF. The proposed spectrometer enables the detection of Earth-mass planets. This will be accomplished with a design innovation that shrinks and stabilizes the spectrometer by employing an octagonal fiber that is split into four smaller fiber-optics, thereby slicing the stellar image to half-size. This design permits the detection of Earth-size planets orbiting inward of the habitable zones of nearby stars.

University of Houston
Steven Baldelli, Kevin Kelly (Rice University)
$1,000,000

Investigators at the University of Houston and Rice University plan to develop a new chemical imaging system and will use it to study fundamental problems in surface chemistry that are otherwise inaccessible. Systems to be investigated include the spatial distribution of surface molecules involved in pattern formation on surfaces such as catalytic reaction on metals or lipids, and Langmuir/Langmuir-Blodgett monolayers, which are important models of biological and cell surfaces. The new technique will combine surface vibrational spectroscopy (sum frequency generation, SFG) and compressive sensing (CS). The planned CS-SFG microscope will allow for the chemical identification and spatial location of molecules on a variety of surfaces and will be applicable to real world samples to provide a chemical map of the interface. The technique will be useful for anyone wanting to characterize or study the surface chemistry of solid or fluid interfaces. The team plans to fully document and publish details of the finished instrument so that others could, affordably, add this imaging modality onto their own systems.

University of Utah
John Belz
$1,000,000

Earth is being bombarded by extremely energetic cosmic radiation from within our galaxy and beyond. It is clear that understanding the origins of these cosmic rays will require accurate models of the most violent processes in the universe. Currently, cosmic rays are studied using detectors covering thousands of square kilometers of the Earth's surface and costing tens of millions of dollars. The sheer scale of these observatories is thus becoming a limitation to our understanding. To overcome this limitation, the team will develop a remote sensing technique known as "bistatic radar." Evidence for the principle behind this technique was first collected by the MARIACHI project, which used high school based cosmic ray detectors and parasitic radar receivers in a very noisy environment to detect the radar echoes of cosmic-ray induced atmospheric plasmas. The investigators on the present proposal aim to repeat the MARIACHI measurements in conjunction with a well-established cosmic ray experiment (Utah's Telescope Array) in a radio-quiet location. They will develop the detection of these atmospheric anomalies into a tool for studying particle astrophysics, thus enabling high-energy cosmic ray research to proceed into the next generation of sensitivity.