Planetary Instrument Concepts for the Advancement of Solar System Observations
Abstracts of Selected Proposals
(NNH15ZDA001N-PICASO15_2)

Below are the abstracts of proposals selected for funding for the Planetary Instrument Concepts for the Advancement of Solar System Observations program. Principal Investigator (PI) name, institution, and proposal title are also included. One hundred thirteen proposals were received in response to this opportunity. On March 30, 2016, twelve proposals were selected for funding.

Don Banfield/Cornell University
Planetary Polarization Nephelometer
The goal of this effort is to develop a novel polarization nephelometer to address outstanding questions about aerosols that reside in the atmospheres of the giant planets, Venus, and Titan relevant to the Planetary Decadal Survey. Building upon previous PIDDP funding and leveraging off of a SBIR that shares mutual design technologies, this proposal plans to take a TRL 3 instrument and mature it to TRL 5. First, component-level maturation demonstrations of the key technologies (i.e., laser drive modulators, receive-side optics and fibers, detector linear array control and readout) will be built. These will then be integrated into a prototype that will be tested under appropriate environmental conditions. The prototype will not be flight qualifiable itself, but will be fabricated using components that have a clear path to flight.

Don Banfield/Cornell University
A Simplified Martian Acoustic Anemometer
The goal of this effort is to develop an acoustic anemometer for Mars and other planetary atmospheres, building on experience from a previous PIDDP. The prior work led to a successful acoustic anemometer with a TRL of 5, but loss of the supplier of the transducers - the main component of the anemometer - brought this instrument back down to TRL 3. The key difference in this application will be aimed at minimizing the resource requirements to still achieve the unique and important science goals for Mars (and other planetary atmospheres) enabled by a fast-response, high-precision wind sensor such as a sonic anemometer. Several candidate transducer technologies that are expected to perform well under Martian conditions, and require significantly less power, mass, and cost to implement for a space flight application will be tested using a new, simpler, signal processing technique. The most promising candidate transducer will be matured for potential future use in space flight.

Lynn Carter/NASA Goddard Space Flight Center
Scalable Beamforming Radar Processor for High Resolution Imaging of Planetary Surfaces
The goal of this effort is to develop a P-band digital beamforming radar concept called the Space Exploration SAR (SESAR) to provide the measurement flexibility to address multiple types of science goals. The proposal describes the design and construction of a prototype of SESAR's Digital Electronics System (DES). The design would leverage proven advanced radar technologies and techniques developed at NASA/Goddard Space Flight Center for Earth-science

airplane radars. The proposed work would reduce the power of the DES by a factor of at least 4, as compared to similar heritage technology, so that it can be used more effectively in future orbital missions. The DES programmable architecture would be able to provide multi-mode radar operation including fully-polarimetric SAR imaging, multi-look angle data collection, nadir SAR altimetry, nadir sounding, and scatterometry for surface and near-subsurface remote sensing.

Nancy Chanover/New Mexico State University

A Fiber-Coupled Plasmonic Spectrometer for In Situ Characterization of Solar System Surfaces

The goal of this effort is to develop a new plasmonic spectrometer to provide *in situ* measurements of volatiles and surface mineralogies. The proposed instrument development program will explore illumination and light gathering strategies for on- or near-surface studies of solar system bodies using optical fibers. The gathered light will then be sent to a plasmonic spectrometer designed using the principles of extraordinary optical transmission. This design enables the transmission of light through sub-wavelength apertures that have been patterned in a metallic film with a regularly repeating periodic structure resulting in excitation of electrons and the formation of a surface plasmon. This instrument would provide high signal-to-noise in the near-infrared, and with the inclusion of optical fibers, could be used for vertical mapping of subsurface layers. The key element in this proposal is the development of a plasmonic filter to provide spectral resolution.

Corey Cochrane /Jet Propulsion Lab

Miniaturized solid-state based vector magnetometer for planetary field mapping

The goal of this effort is to develop a solid-state magnetometer based on SiC diode technology that can compete with and potentially replace heritage magnetometers such as those using fluxgate and optically pumped atomic gas. The proposal would study the performance of a range of preexisting diodes, received from a variety of SiC processing facilities and determine the parameters that lead to the best performing sensor. The team would then fabricate a new SiC device that has its performance tailored for precise and accurate magnetic field sensing to meet science missions, integrating the new sensor into an existing magnetometer and testing its performance. In addition, an aim is to improve analog circuitry and signal processing software to optimize the sensitivity and stability of the magnetometer.

Robert Graham Cooks/Purdue University

New Scan Modes in Ion Trap Mass Spectrometers for Planetary Exploration

The goal of this effort is to develop modifications to the operation of a quadrupole mass filter and the quadrupole ion trap to allow secular frequency scanning as opposed to amplitude scanning. The new modes would enable increased operating pressure, increased signal/noise ratios, and allow new types of scans, (e.g. precursor scans) in single analyzers. The modifications would include Hadamard multiplexed detection to increase signal/noise ratios and secular frequency scans to record mass spectra as well as MS/MS scans. The experiments would be implemented on both commercial and lab-built miniature instruments. Ions will be generated from solutions and from solids using ambient ionization methods.

Jason Corliss/University of Arizona
All-Reflective Spatial Heterodyne Spectroscopy: Extending High Sensitivity Velocity Resolved Measurements of Solar System Dynamics into the EUV
The goal of this effort is to develop a new high spectral resolution capability for the extreme ultraviolet (EUV). The EUV spectral region contains ion and neutral transitions that track energetic processes in the solar system at scales from planetary upper atmospheres to the entire heliosphere. EUV signatures are typically associated with transition effects such as shock boundaries, energy deposition sites (aurorae & ionospheres), magnetic field aligned accelerations and gryo-motion (in magnetospheres or the solar corona), plasma pickup processes (e.g. Io plasma torus, comet ion tails, planetary exospheres) and interactions between different particle populations (e.g. resonant charge exchange). The goal of this proposed effort is to address the 'resolution gap' in EUV spectroscopy through demonstration of an all-reflective, common-path EUV spatial heterodyne spectrometer (ARCSHS). The instrument will be based upon several existing, proven instrument designs.

Robert E. Grimm/Southwest Research Institute
Airborne Electromagnetic Sounding of the Interiors of Venus, Mars, and Titan
The goal of this effort is to develop a prototype high-altitude airborne electromagnetic sounding system and to test the prototype on a stratospheric balloon for the purpose of studying lithospheric structures such as those on Venus, ground water on Mars, and subsurface ocean on Titan. Specifically, the goal is to demonstrate that extremely low frequency to ultralow frequency waves in the transverse electromagnetic band can characterize the induced horizontal component of the electric field in the stratosphere and to interpret these properties in terms of frequency-dependent resistivity of the ionosphere and the ground. The team would build a Balloon-borne, Transverse ElectroMagnetic wave-sensing system (BTEM) consisting of electrometers, magnetometers, inertial navigation system, computer and battery, fly BTEM on a stratospheric balloon to a maximum altitude of 20-30 km, and demonstrate that the depth-dependent electrical conductivity of the ground (and ionosphere) can be determined from these data. A separate NASA contract will fund the balloon, gondola and recovery.

Jonathan Grindley/Harvard
Miniature Lightweight X-ray Optics for Solar System Exploration
The goal of this effort is to develop a new type of Miniature X-ray Optics (MiXO) that brings highly successful Wolter-I X-ray optics to planetary science within affordable mass, power, and cost constraints. The proposed optics offer flexible and affordable observing opportunities and would enable efficient X-ray telescope configurations that can identify the elemental composition of a wide range of planetary bodies. This program proposes to build three prototype MiXO modules, bringing the technology from TRL 2 to 4 by its end. The effort will demonstrate the technical feasibility and advantage of MiXO by building progressively higher performance prototypes of MiXO, and will also enable several MiXO designs that can be readily adopted in a wide range of future planetary missions.

Maria Fernanda Mora/Cal Tech-JPL
Microfluidic Ion Analyzer for Astrobiological Studies
The goal of this effort is to develop a universal conductivity-based detector (C4D) into a lab-on-a-chip system that can search for salts and biomarkers simultaneously while greatly simplifying both the instrument and its operation. The three key research objectives are to develop protocols for simultaneous analysis of inorganic and organic ions with microelectrophoretic separation (ME) and -C4D; to demonstrate analysis of inorganic and organic ions by ME-C4D in relevant environmental samples, and to design a miniaturized ME-C4D instrument. The instrument will be capable of detecting ionic species directly in liquid samples, following extraction from solid samples, or from melted of ice samples.

Jorge Núñez/Johns Hopkins University Applied Physics Laboratory
Advanced Multispectral Infrared Microimager (AMIM) for Planetary Surface Exploration
The goal of this effort is to develop an Advanced Multispectral Infrared Microimager (AMIM), a compact microscopic imager that would be capable of providing mineralogy of rocks and soils within a microtextural context. AMIM consists of compact, low-power multispectral LED arrays coated with narrow-bandpass filters (> 25 wavelengths with FWHM ≤ 50 nm), an adjustable focus mechanism capable of focusing from a distance of ~30 mm (spatial resolution ≤ 30 μm/pixel) to infinity, and an infrared camera capable of imaging from the visible/near-infrared to shortwave-infrared. AMIM would eliminate the need for a filter wheel, grating system, multiple detectors, or tunable filters. This would reduce the mass, size, power consumption, risk, and complexity compared to larger imaging spectrometers, enabling it to be deployed on a lander or rover.

Thomas Prettyman/Southwest Research Institute
Ultra-bright scintillator for planetary gamma ray spectroscopy
The goal of this effort is to develop a gamma ray spectrometer that is based on strontium iodide (SrI_2), a new inorganic scintillator material. The proposed instrument will utilize new silicon photomultipliers (SiPMs) as readout for the scintillator and promises to provide better energy resolution (<4% at 622 keV) than current scintillator based gamma ray spectrometers. The proposed efforts address key issues such as the technical approach for growing bigger SrI_2 crystals, neutron and proton activation evaluation, modeling of expected fluxes, electronics optimization for readout, and the implementation of appropriate software for spectral analysis. The proposed effort will advance this concept from a TRL level of 2 to 3.