Opportunity Title: Solar System Exploration: Theoretical and Observational Studies in Astrochemistry
Opportunity Reference Code: 0115-NPP-NOV23-GSFC-PlanetSci

Organization National Aeronautics and Space Administration (NASA)

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Application Deadline 11/1/2023 6:00:59 PM Eastern Time Zone

Description Our research group undertakes research in astrochemistry and molecular astrophysics aimed at understanding those astronomical envrionments that are to be studied by current and future NASA missions. We are particularly interested in the chemical connections between different stages in the Galactic evolution of matter, specifically issues related to the birth and death of stars, the formation and evolution of the Solar System, and prebiotic chemistry.
Our theoretical work involves identifying and undertanding the basic chemical processes that drive gas-phase and solid-phase chemistry in different extraterrestrial environments. We then apply these concepts to construct detailed computer models of various astronomical sources. The theoretical models involve either numerical integration of large systems of differential equations describing combined dynamical-chemical evolution, as in the case on cometary comae, or involving stochastic simulation using Monte Carlo alogorithms, as in the case of catalytic reactions on astronomical dust particles. We are interested in the chemistry of the interstellar molecular clouds that give brth to both massive and low-mass stars, and the effects these young stars have on their surroundings. Associated with the collapse of a molecular cloud core to form a star like the Sun, is the formation of an orbiting disk of gas and dust which eventually evolves into a planetary system. Chemical models are under development which will allow us to follow the chemical evolution of interstellar material as it becomes incorporated into these disks. We are also constructing models of chemical evolution in protoplanetary disks for comparison with current and furture astronomical observations. We particularly interested in the record of chemistry in the protosolar nebula that is contained in primitive Solar System matter, such as asteroids, meteorites and comets, and so many of our models incorporate detailed isotopic fractionation chemistries. A strong focus is given to undertanding the formation of organic molecules as this is directly relevant for astrobiology. The cometary populations probably contains some of the most pristine materials in the Solar System. Remote observations of cometary molecules probe directly the gaseous coma as it outgasses from the nucleus of dust and ice. A significant effort at GSFC is in the development of a coma chemistry code and applying it to understand the data both from ground-based observtaions and from comet rendezvous space missions. A model of the physiccal and chemical evolution of the cometary nucleus is also under development. When stars like the Sun begin to die they first evolve into red giants and then evolve along the Asymptotic Giant Branch. Red giants form massive, chemically-rich, circumstellar envelopes and are copious producers of dust grains and complex molecules. Detailed dynamical-chemical modeling is undertaken to understand the molecular processes that occur both in the dust formation zone and in the outer envelops as dust and gas flow out into the interstellar medium. These

models are directly applicable to the interpretation of data now being returned by the Herschel Space Observatory. Opportunities for theoretical research exist in several areas and proposals that offer the possibility of cross-fertilization between these are encouraged.

We also are active in using radio telescopes to study the chemistry of these same regions of the galaxy. The rich molecular inventory found in solar system materials, such as meteorites and cometary particles returned from STARDUST, have interstellar heredity, known due to abnormal isotopic signatures as well as numerous non-terrestrial species in prebiotic classes (such as amino acids). This chemical complexity may have survived the formation of the solar system, or such large organics may have been formed during this process. Observations of complex species throughout the Galaxy towards objects at various stages of stellar evolution may help elucidate the extent of prebiotic chemical heritage. Many regions associated with this evolutionary sequence are not accessible by infrared, visible, or ultraviolet wavelengths due to the dark and cold nature of these objects. Thus, millimeter and submillimeter wavelengths are excellent probes to access the molecular content as well as ascertain the physical conditions of these objects. Abundance variations, molecular inventory, isotope ratios in various species, and molecular distributions can be determined from observations at these wavelengths and help decipher the origins and/or survival of molecular material throughout the interstellar medium. Specific research opportunities may include millimeter and/or submillimeter observations of the interstellar medium, circumstellar envelopes, and/or comets to investigate the molecular complexity throughout stellar evolution, including the formation of planetary systems and astrobiological implications. Additionally, observations of direct relevance to astrobiology are conducted, and involve the search for new organic molecules in interstellar clouds that may have been important for prebiotc chemistry on the early Earth.

Location:
Goddard Space Flight Center
Greenbelt, Maryland

Field of Science: Planetary Science

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Applications with citizens from Designated Countries will not be accepted at this time, unless they are Legal Permanent Residents of the United States. A complete list of Designated Countries can be found at: https://www.nasa.gov/oiir/export-control.

Eligibility is currently open to:

- U.S. Citizens;
- U.S. Lawful Permanent Residents (LPR);
- Foreign Nationals eligible for an Exchange Visitor J-1 visa status; and,
- Applicants for LPR, asylees, or refugees in the U.S. at the time of application with 1) a valid EAD card and 2) I-485 or I-589 forms in pending status

Eligibility Requirements

- **Degree:** Doctoral Degree.