NASA SBIR 2022 Phase I Solicitation

S14.02 Particle and Field Sensors and Instrument-Enabling Technologies

Lead Center: GSFC

Participating Center(s): MSFC

Scope Title

Particles and Fields Sensors and Instrument Enabling Technologies

Scope Description

The 2013 National Research Council's "Solar and Space Physics: A Science for a Technological Society" motivates this subtopic: "Deliberate investment in new instrument concepts is necessary to acquire the data needed to further solar and space physics science goals, reduce mission risk, and maintain an active and innovative hardware development community." This subtopic solicits development of advanced in situ instrument technologies and components suitable for deployment on heliophysics missions. Advanced sensors for the detection of neutral and ionized gases (atoms, molecules, and ions) and their motions (winds and ion drifts); energetic particles (electrons and ions), including their energy distribution and pitch angles; thermal plasma populations, including their temperature; and direct current (DC) and wave electric and magnetic fields in space along with associated instrument technologies are often critical for enabling transformational science from the study of the Sun's outer corona, to the solar wind, to the trapped radiation in Earth's and other planetary magnetic fields, and to the ionospheric and upper atmospheric composition of the planets and their moons.

These technologies must be capable of withstanding operation in space environments, including the expected pressures, radiation levels, launch and impact stresses, and range of survival and operational temperatures. Technology developments that result in a reduction of mass, power, volume, and data rates for instruments and instrument components without loss of scientific capability are of particular importance. In addition, technologies that can increase instrument resolution and sensitivity or achieve new and innovative scientific measurements are solicited.

Improvements in particle and field sensors and associated instrument technologies enable further scientific advancement for upcoming NASA missions such as CubeSats, Explorers, Solar Terrestrial Probe (STP), Living With a Star (LWS), and planetary exploration missions. Specifically, this year the subtopic solicits instrument development that provides significant advances in the following areas:

- Compactly stowed, lightweight, long, straight, and rigid booms, magnetically clean, that can deploy a sensor with embedded electronics to distances of 2 m or longer on CubeSat and SmallSat constellations in order to measure DC magnetic fields.
- Compactly stowed, lightweight, long, straight, and rigid booms that can deploy a sensor with embedded electronics to distances of 6 m or longer on satellites and sounding rockets in order to measure DC electric fields and plasma waves. Mass target: 1 kg or less.
- Solar-blind solid-state detectors (SSDs) for direct solar viewing energetic particle detection. The SSDs...
should be able to handle the intense ultraviolet (UV) and visible solar radiation without saturation, with low noise while addressing thermal issues. Typically, a metalized foil is used for UV suppression, but this gives an energy threshold of 1 MeV or more. The target energy threshold for the SSD is ~50 keV or lower with the upper energy range in the several to tens of megaelectronvolts. Pushing the threshold down will increase performance and reduce cost over the current instrument designs.

- Rapid electrostatic analyzer production/high-tolerance assembly for plasma instruments. This will be especially useful for multiple instrument production for constellation missions.

**Expected TRL or TRL Range at completion of the Project**

2 to 4

**Primary Technology Taxonomy**

**Level 1**

TX 08 Sensors and Instruments

**Level 2**

TX 08.X Other Sensors and Instruments

**Desired Deliverables of Phase I and Phase II**

- Prototype
- Hardware

**Desired Deliverables Description**

Phase I deliverables: Concept study report, preliminary design, and test results.

Phase II deliverables: Detailed design, prototype test results, and a prototype deliverable with guidelines for in-house integration and test (I&T).

**State of the Art and Critical Gaps**

- Compactly stowed, lightweight, long, straight, and rigid booms, magnetically clean, that can deploy a sensor with embedded electronics to distances of 2 m or longer on CubeSat and SmallSat constellations in order to measure DC magnetic fields.
- Compactly stowed, lightweight, long, straight, and rigid booms that can deploy a sensor with embedded electronics to distances of 6 m or longer on satellites and sounding rockets in order to measure DC electric fields and plasma waves. Mass target: 1 kg or less.
- Solar-blind SSDs for direct solar viewing energetic particle detection. The SSDs should be able to handle the intense UV and visible solar radiation without saturation, with low noise while addressing thermal issues. Typically, a metalized foil is used for UV suppression, but this gives an energy threshold of 1 MeV or more. The target energy threshold for the SSD is ~50 KeV or lower with the upper energy range in the several to tens of megaelectronvolts. Pushing the threshold down will increase performance and reduce cost over the current instrument designs.
- Rapid electrostatic analyzer production/high-tolerance assembly for plasma instruments. This will be especially useful for multiple instrument production for constellation missions.

**Relevance / Science Traceability**

Particle and field instruments and technologies are essential bases to achieve the Science Mission Directorate's (SMD’s) Heliophysics goals summarized in the National Research Council’s, Solar and Space Physics: A Science for a Technological Society. In situ instruments and technologies play indispensable roles for NASA’s LWS and STP mission programs, as well as a host of smaller spacecraft in the Explorers Program. In addition, there is
growing demand for particle and field technologies amenable to CubeSats and SmallSats. NASA SMD has two
excellent programs to bring this subtopic technologies to higher level: Heliophysics Instrument Development for
Science (H-TIDeS) and Heliophysics Flight Opportunities for Research and Technology (H-FORT). H-TIDeS seeks
to advance the development of technologies and their application to enable investigation of key heliophysics
science questions and space weather. This is done through incubating innovative concepts and development of
prototype technologies. It is intended that Phase II and III technologies, further developed through H-TIDeS, would
then be proposed to H-FORT to mature by demonstration in a relevant environment. The H-TIDeS and H-FORT
programs are in addition to Phase III opportunities. Further opportunities through SMD include Explorer Missions,
New Frontiers Missions, and the upcoming Geospace Dynamics Constellation.

References

- National Research Council: "Solar and Space Physics: A Science for a Technological
  Society," [http://nap.edu/13060](http://nap.edu/13060)
- Example missions (e.g., NASA Magnetospheric Multiscale (MMS) mission, Fast Plasma Instrument; Solar
  Probe; STEREO; and Geospace Dynamics Constellation): [http://science.nasa.gov/missions](http://science.nasa.gov/missions)