NASA SBIR 2018 Phase I Solicitation

S1.09 Cryogenic Systems for Sensors and Detectors

Lead Center: GSFC

Participating Center(s): ARC, JPL, MSFC

Technology Area: TA8 Science Instruments, Observatories & Sensor Systems

Cryogenic cooling systems often serve as enabling technologies for detectors and sensors flown on scientific instruments as well as advanced telescopes and observatories. As such, technological improvements to cryogenic systems further advance the mission goals of NASA through enabling performance (and ultimately science gathering) capabilities of flight detectors and sensors. There are four potential investment areas that NASA is seeking to expand state of the art capabilities for possible use on future programs such asÂ the Europa Jupiter System Science missions (http://www.nasa.gov/multimedia/podcasting/jpl-europa20090218.html), and flagship missions under consideration for the 2020 Astrophysics Â Decadal Survey (http://cor.gsfc.nasa.gov/docs/PCOS_facility_missions_report_final.pdf). The topic areas are:

Cryocooler Systems and Components:

- *Miniaturized/Efficient Cryocooler Systems* - Cryocooler systems are sought for application on SmallSat and small low power instrumentÂ space platforms. Â Present state-of-the-art capabilities provide 0.4 W of cooling at 77 K with approximately 5 W input power, while rejecting heat at 300 K, and having a system mass of 400 grams. Desired performance specifications for cryocoolers include a cooling capability on the order of 0.2 W at a temperature of approximately 30 K. For application on missions to outer planets, cryocoolers are needed with a cooling power of 0.3 W at approximately 35 K, with a heat rejection temperature as low as 150 K. Â Desired masses and input powers in both cases are < 400 grams and < 5W respectively.Â Component level improvements are also desirable.
- *Low Temperature/High Efficiency Cryocoolers* -Â High efficiency, multi-stage coolers with a low temperature stage capable of reaching 4 to 10 K will be needed for future astrophysics missions. Â Current state-of-the-art coolers include a device providing 0.04 W at 4.5 K and another providing 0.09 W at 6 K. Â Cryocoolers are sought that provide higher cooling power, for example >0.3 W at 10 K and ~ 200 mW at 4 K, with high efficiency. Â Devices that produce extremely low vibration, particularly at frequencies below a few hundred Hz are of special interest. Component level improvements are also desirable.
- *Cryogenic/Rad-Hard Accelerometers* -Â Accelerometers that can operate at 150 K, withstand a 0.01 Tesla magnetic field and are radiation hard to mega-rad level doses are needed for cryocooler control and monitoring in missions to outer planets.

Sub-Kelvin Cooling Systems:Â

- *Magnetic Cooling Systems* - Sub-Kelvin cooling systems include Adiabatic Demagnetization Refrigerators (ADRs) and Active Magnetic Regenerative Refrigerators (AMRRs). The ADR in the Soft X-ray Spectrometer instrument on the Hitomi mission represents the state of the art in sub-Kelvin cooling systems for space application. Future missions requiring sub-Kelvin coolers will need devices that provide lower operating temperature (<50 mK), higher (preferably 100%) duty cycle, higher heat rejection temperature (preferably > 10K), higher overall system efficiency, and lower mass. Improvements at the component level are needed to achieve these goals. Specific components sought include:
    - Compact, lightweight, low current superconducting magnets capable of producing a field of at least 4 Tesla while operating at a temperature of at least 10 K, and preferably above 15 K. Â Desirable properties include:
        - A high engineering current density, preferably > 300 Amp/mm^2.
        - A field/current ratio of >0.33 Tesla/Amp, and preferably >0.66 Tesla/Amp.
        - Low hysteresis heating.
    - Lightweight Active/Passive magnetic shielding (for use with 4 Tesla magnets) with low hysteresis and eddy current losses, and low remanence.
    - Heat switches with on/off conductance ratio > 3 10^4 and actuation time of <10 s. Â Materials are also sought for gas gap heat switch shells: these are tubes with extremely low thermal conductance below 1 K; they must be impermeable to helium gas, have high strength, including stability against buckling, and have an inner diameter > 20 mm.Â
    - High cooling power density magnetocaloric materials, especially single crystals with volume > 20 cm^3.
    - Superconducting leads (10K - 90K) capable of 10 A operation with 1 mW conduction.
    - 10 mK- 300 mK high resolution thermometry.Â
    - Proposals considered viable for Phase I award will seek to validate hypotheses through proof of concept testing at relevant temperatures.