N90-27811

UPCOMING PLANETARY MISSIONS AND THE APPLICABILITY OF HIGH TEMPERATURE SUPERCONDUCTOR BOLOMETERS

J. Brasunas, V. Kunde, NASA/Goddard, Code 693.2, Greenbelt, MD 20771; H. Moseley, NASA/Goddard, Code 685, Greenbelt, MD 20771; B. Lakew, STX Corporation, Lanham, MD 20706

Planetary missions to Mars and beyond can last 11 years and longer, making impractical the use of stored cryogens. Passive radiative coolers and single-stage mechanical coolers remain possibilities, although the power and mass of the mechanical cooler may prove problematical. Either option can provide about the same lower limit of temperature, which in the case of the Galileo mission to Jupiter is 75 K for a radiatively cooled focal plane.

For these temperatures far infrared (longer than 25 μm wavelength) observations are completely limited by detector performance. While high sensitivity InSb detectors may be used at 5 μm and somewhat lower sensitivity HgCdTe detectors may be used out to 20 μm or so, beyond 25 μm low sensitivity, essentially room-temperature thermal detectors must be used. These thermal detectors are no better than the Schwarz-type thermopile used on Voyager/IRIS, launched in 1977 to Jupiter, Saturn, Uranus and Neptune. No thermal detector currently takes advantage of operation at ~75 K, where the thermal noise is ~30 times lower than at 300 K.

CRAF and CASSINI, both using the newly developed Mariner Mark II spacecraft, will be the next outer planet missions after Galileo; they are intended to provide information on the origin and evolution of the solar system. CRAF is a cometary rendezvous mission slated for a 1994 launch. CASSINI has been chosen by ESA as its next science new start in the face of stiff competition, may be selected by NASA for a fiscal year (FY) 90 new start, and will be launched by a Titan IV/Centaur in 1996. It will fly by Jupiter in 2000, inject an ESA-supplied probe into Titan in 2002, and take data in Saturn orbit from 2002 to 2006.

NASA/Goddard is currently developing a prototype Fourier transform spectrometer (CIRS) under PIDDP funding (Planetary Instrument Definition and Development Program) that will be proposed for the CASSINI mission. The baseline infrared detectors for CIRS are HgCdTe to 16 μm and Schwarz-type thermopiles from 16 to 1000 μm. The far infrared focal plane could be switched from thermopiles to high temperature superconductor (HTS) bolometers between now and 1996.

An HTS bolometer could be built using the kinetic inductance effect, or the sharp resistance change at the transition. The transition-edge bolometer is more straightforward to implement and initial efforts at NASA/Goddard have been directed to that device. With internal funding (DDF, the Director's Discretionary Fund), Goddard has been collaborating with NIST/Boulder starting in FY 88 to develop an HTS bolometer. A working device was made and tested in early 1989- it is too slow to yet be useful. It also has somewhat elevated noise levels

below 100 Hz. This effort will be continued beyond FY 89 using a second PIDDP grant.

Upcoming efforts will center on reducing the time constant of the HTS bolometer by attempting to deposit an HTS film on a diamond substrate, and by thinning $SrTiO_3$ substrates. Attempts will be made to improve the film quality to reduce the 1/f noise level, and to improve the thermal isolation to increase the bolometer sensitivity. If a sensitive HTS bolometer is produced attention will also have to be directed to long-term stability, radiation hardness, thermal cycling and vibration-induced damage. Simultaneously, Goddard is funding research through the SBIR program (Small Business Innovation Research) to attempt to deposit good-quality HTS films on diamond films using an MOCVD technique