The Science Capability Of The Low Temperature Microgravity Physics Facility

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Abstract

The Low Temperature Microgravity Physics Facility (LTMPF) is a multiple user and multiple-flight NASA facility that will provide a low temperature environment for about 4.5 months on board the International Space Station (ISS). The LTMPF will be attached to the Japanese Experiment Module (KIBO) Exposed Facility of the ISS. The Jet Propulsion Laboratory is developing the Facility for its initial flight in late 2005. The LTMPF will provide a reusable platform to enable state of the art experiments requiring both low temperatures and microgravity conditions. During each mission, two distinct primary experiments will be accommodated, as well as secondary experiments that can utilize the as built hardware.

Key words: superfluid; dewar; space

1. Introduction

The Jet Propulsion Laboratory (JPL) was instrumental in the development of the first liquid helium cooled satellite, the Infrared Astronomical Satellite (IRAS)[1], which flew in 1983. IRAS was extremely successful, both for wealth of the astronomical data returned, and for proving that superfluid helium could be used to cool an experiment below 2K in a microgravity environment. Also in the 1980's, JPL developed the Low Temperature Platform Facility (LTPF)[2] for short duration (1 to 2 weeks) low temperature condensed matter experiments on the Space Shuttle. The LTPF flew three times: in 1985 as the Superfluid Helium Experiment[3], in 1992 as the Lambda Point Experiment[4], and in 1997 as the Confined Helium Experiment (CHeX)[5]. Unfortunately, by 1997 the construction of the International Space Station (ISS) at least temporarily brought about the end of opportunities to fly the LTPF on the Space Shuttle.

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While the construction of the ISS has caused the loss of Space Shuttle opportunities, a new opportunity for long duration microgravity research has been created. To take advantage of the opportunity provided by the ISS, a new low temperature platform, the Low Temperature Microgravity Physics Facility (LTMPF), is being developed by JPL in collaboration with industrial and university partners. This new facility will enable breakthrough scientific investigations requiring both low temperatures and microgravity conditions.

2. Objectives and Description

The objective of the LTMPF is to expand on the capabilities of the LTPF by providing: more frequent access to space (every 2 versus 5 years), a longer duration of low temperatures (4.5 months versus 2 weeks), and support for two independent experiments per flight. These improvements will significantly increase the quantity and quality of science returned.

The LTMPF is a self contained, reusable, cryogenic facility that will attach to the Japanese Experiment

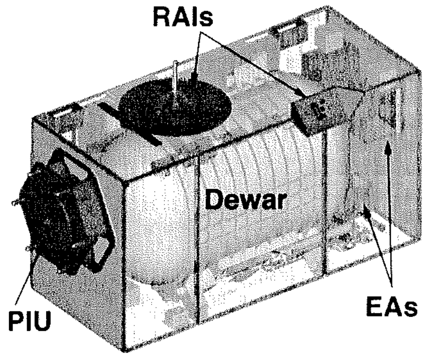

Fig. 1. A line drawing of the LTMPF showing the JEM-EF attachment (the PIU), The robotic arm interfaces (RAIs), the dewar, and the electronics (EA's).

Module Exposed Facility (JEM-EF) on the ISS. The LTMPF consists of a superfluid helium dewar, two experiment instruments, electronic assemblies (EA's) for the facility and each experiment, an enclosure, and interfaces for the Shuttle, the robotic arms, and the JEM-EF (the Payload Interface Unit (PIU)) (see Figure 1). It fits within an envelope of 1.85m X 1.0m X 0.8m, with a total mass less than 600kg.

JPL is developing the LTMPF in partnership with: Ball Aerospace and Technologies Corporation, Design-Net Engineering, Swales Aerospace, and the Principal Investigators and their teams at the University of New Mexico, JPL, the University of California at Santa Barbara, and Stanford University. Ball is building the dewar and the enclosure for the facility. Design-Net Engineering is providing most of the electronics and software. The Principal Investigators are developing the experiment unique hardware, electronics, and software. JPL will integrate and test all of the components of the LTMPF and support launch and on orbit operations.

3. Capabilities

The LTMPF dewar has openings on each end of the helium reservoir to mount instruments. Two instruments are installed inside independent vacuum cans, 20 cm in diameter and 45 cm long. Each instrument consists of an experiment specific sensor package developed by the investigator and a cryo insert provided by JPL as a standard thermal mechanical interface.

The LTMPF incorporates a variety of high resolution sensors for use by the experiments including DC Superconducting Quantum Interference Devices (SQUIDs), high resolution capacitance bridges, high resolution resistance bridges, and high precision heater controllers and readouts. LTMPF has increased the resolution, number, and type of sensors available compared with the LTPF, enabling a more diverse set of investigations.

4. Status

The LTMPF is in the detailed design phase. Several long lead components are in fabrication including the helium dewar and the cryo insert. Also, prototypes of several critical pieces of hardware, including electronics, and the instrument sensor packages for the experiments on the first mission, have been successfully tested. All the components of the Facility will be integrated at JPL in early 2004.

Six experiments have been selected to fly on the LTMPF: two primary experiments for each of the first two missions, and two guest investigations for the first mission. The investigations were selected through the NASA Research Announcement (NRA) proposal process. Future investigations will also be selected using the NRA process.

5. Conclusion

The LTMPF will provide the unique environment of low temperature and microgravity for experiments desiring a long duration for data collection. When the facility is launched in late 2005, it will provide exciting new science investigation opportunities onboard the International Space Station. JPL will provide the necessary infrastructure and service to enable a user-friendly interface to the scientific community, making easy and low cost access to space a reality for scientists.

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