National Aeronautics and Space Administration

# The 650-Gallon Dewar

One of the greatest technical challenges for Gravity Probe B is to keep its science instrument constantly supercooled. For the relativity experiment to operate properly, the science instrument must be kept at **1.8 Kelvin (-271.4 degrees Celsius)** constantly for one to two years.

Initially, the science instrument is cooled by placing it in a **dewar,** a special 650-gallon "thermos", filled with liquid helium in a superfluid state. The nine-foot tall dewar is the main structure of the satellite itself. However, once the GP-B satellite is in polar orbit above the Earth, it passes through Earth's shadow and into intense sunlight every ninety minutes. If the Sun's radiation raises the temperature of the GP-B science instrument just a single degree, the experiment will fail.

The dewar has several systems designed to limit any changes in temperature within the dewar including: (1) multilayer insulation -- multiple reflective surfaces in the vacuum space to cut down radiation; (2) vapor-cooled shields -- metal barriers, suitably spaced, cooled by the escaping helium gas; (3) Passive Orbital Disconnect Struts (PODS) -- rigid launch supports, invented by Lockheed Martin, which relax on orbit to give looser support with less heat flow.

One of the most critical devices for stabilizing the GP-B temperature is a **"porous plug"**, which was invented at Stanford and engineered for space at NASA Marshall Space Flight Center and the Jet Propulsion Laboratory. This plug has the unique ability to allow helium gas to escape while containing the liquid helium. It acts like a sponge on the gas, "wicking" it out of the dewar.

Releasing the helium gas aids the experiment in three ways. First, it limits the "bump-boiling" effect. Despite all the thermal protection provided, some liquid helium will gradually heat up and become helium gas. If this gas stayed in the dewar its atoms would "bump" into the liquid atoms and transfer heat energy, causing more liquid to "boil" which would create more gas which would then heat more liquid and so on. By releasing this gas as it is produced, the "bump-boiling" process is slowed considerably.

Second, the evaporating helium provides its own kind of refrigeration. As the helium gas escapes from the dewar, it carries heat energy with it. The liquid helium in the dewar loses this energy and becomes colder still. You can feel this effect on your skin when you swab your skin with alcohol or room temperature water. As the liquid evaporates off your skin, it draws heat energy with it, leaving your skin a tiny bit cooler than before.

Third, the escaping helium gas is directed through several positioning valves to control the satellite's position. To turn the satellite, the gas flow is slightly reduced or increased through the appropriate side. If the porous plug was not allowing the helium gas to escape, the satellite could not maintain its precise positioning.

**About The Image**

A Gravity Probe B scientist wearing a "clean suit" inspects the nine-foot high dewar as it sits in a frame specially designed to support it during tests.

For more information, comments or questions, contact GP-B at www@relgyro.stanford.edu or visit http://einstein.stanford.edu/

LTH3.1-1003

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