National Aeronautics and
Space Administration

Keeping Our Cool Near Absolute Zero

Gravity Probe B

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)** for at least one year. Key portions of the science instrument must be maintained at a constant temperature to within five millionths of a degree celsius (+/- 0.000005˚C).

Initially, the science instrument is cooled by placing it in a **dewar,** a special 645-gallon "thermos", filled with superfluid liquid helium. The nine-foot tall dewar is the main structure of the satellite itself. Like all thermos bottles, the inside of the dewar has a vacuum, which limits the amount of heat penetrating through the outside wall into the inner chamber containing the science instrument.

However, once the GP-B satellite is in polar orbit above the Earth, keeping it supercooled becomes significantly harder. During the year, it is exposed to the Sun's light for irregular amounts of time depending on the where the Earth is in its orbit around the Sun. Several other systems had to be developed to assist the dewar in maintaining the supercooled liquid helium.

Structurally, the dewar has multi-layer insulation and vapor-cooled sheilds. The multi-layer insulation has multiple reflective surfaces in the vacuum space to cut down on any penetrating radiation. The vapor-cooled shields provide metal barriers, suitably spaced, that are cooled by the escaping helium gas.

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, 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 when alcohol or 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.

For more information, comments or questions,
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