National Aeronautics and Space Administration

The World's Roundest Gyroscopes

Gravity ProBe

In order for Gravity Probe B to measure any "twist" or curvature of local spacetime, it must use a gyroscope that is nearly perfect—one that will not wobble or drift more than 0.000000000001 degrees in an hour while it is spinning. It must be this precise because the predicted twist of local spacetime is smaller than 0.0000001 degree each year!

A nearly-perfect gyroscope must be nearly perfect in two ways: sphericity and homogeneity. Every point on its surface must be exactly the same distance from the center (a perfect sphere), and its structure must be identical from one side to the other (homogenous).

After years of research and development, Gravity Probe B produced just such a gyroscope. It is a 1.5-inch sphere of fused quartz, polished and "lapped" to within a few atomic layers of perfect sphericity. A scan of its surface shows that only *.01 microns* separate the highest point from the lowest point. Transform the gyroscope into the size of the Earth and its highest mountains and deepest ocean trenches would be *a mere eight feet from sea level*! It is the most spherical object ever made, and more spherical than most things in the universe, rivaled only by extremely dense neutron stars!

Inside, the gyroscope is solid fused quartz. The quartz was chosen from a mine in Brazil and shipped to a refining plant in Germany. In Germany, it was separated, smelted, molded, then smelted and molded again, gradually removing its impurities. By the time it reached Gravity Probe B, the fused quartz blocks were some of the purest materials in the world, setting the ISO standard for material homogeneity (International Standards Org.) .

The gyroscopes were ground and polished from only the purest of pure quartz. When examined using a unique refractive comparison method, the gyroscope's quartz structure was identical throughout to within two parts in a million. That is like having every person in a city of 1,000,000 people be your identical twin except for two!

ABOUT THE IMAGE

Gravity Probe B gyroscope (rotor) with quartz housing halves. Each quartz rotor is coated with niobium, a superconducting metal. Inside each housing, three electrodes electrically suspend the gyroscope allowing it to spin freely at 10,000 rpm. Channels are cut in the quartz housing to allow helium gas to start the rotor spinning. A wire loop embedded in the housing connects to an external SQUID to detect any change in direction of the gyroscope's axis.

FAST FACTS

Gyro Size
1.5 inches of fused quartz

Sphericity
< 40 atomic layers from perfect

Quartz Purity
Within 2 parts per million

Gyro Spin Rate
~10,000 rpm

Gyro Drift Rate
$< 10^{-12}$ degrees/hour

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

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