AVIATION WEEK

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By Frank Morring, Jr.

NASA's $700 million Gravity Probe B (GP-B) experiment has demonstrated two key aspects of Albert Einstein's General Theory of Relativity, but not to the hoped-for degree of confidence because of the complexity of making the extremely subtle measurements in space.

The project generated valuable technology and scientific spin-offs, including 100 new Ph.D. scientists whose graduate work contributed to GPB. It also taught some important lessons on the risks associated with tackling such an ambitious project.

After five years of data processing to eliminate unexpected system noise that obscured the spacetime "frame-dragging" effect predicted from Einstein's theory, researchers were able to claim only a 20% margin of error in declaring success.

They had hoped for 1% or better, which they achieved with a second measurement of what is known as the geodetic effect.

Using Einstein's theory, the experiment's designers calculated that the rotors would drift off the guide star by 6,606.1 milliarcseconds over a year because of the geodetic effect – basically, the effect of Earth's gravity on spacetime.

For frame-dragging, which has been compared to spinning a bowling ball in a pool of molasses, the predicted value was 39.2 milliarcseconds.

The final results, as presented by GP-B Principal Investigator Francis Everitt of Stanford University at NASA headquarters May 4, were a geodetic drift of 6,601.8 milliarcseconds (±18.3), and a frame-dragging drift of 37.2 milliarcseconds (±7.2).

The team published its findings in the journal Physical Review Letters.

"The frame-dragging we've measured to a little better than 20%, so that's the results of the experiment," Everitt says.

Achieving the precision necessary for such fine measurement required development of 13 new spacecraft technologies and produced a unique spacecraft that merged its instrument, guidance and control functions into a single system.

Basically, GPB was a 3.4-ton satellite built to keep four almost-perfect spheres of fused quartz and silicon about the size of pingpong balls spinning at 5,000 rpm without interference.

Unfortunately, there was an unanticipated electric polarity in the rotors' niobium layer that manifested as surface magnetic fields when they were spun up. Ground testing had not detected it, and it proved extremely complicated to process out, underscoring the risks of trying to build such a complex spacecraft.

But some of the GPB technology has found its way into other spacecraft, including a porous plug used to manage the liquid helium that cooled the gyros to 1.8K. That technology in turn enabled NASA's Cosmic Background Explorer, which won John Mather and George Smoot the 2006 Nobel Prize in Physics for work with that spacecraft confirming the big-bang theory.

"When people started thinking about how to measure the cosmic background, I don't think they were thinking very hard about how to manage a superfluid helium dewar," said Teledyne Brown Engineering President Rex Geveden, who was the GP-B project manager at the Marshall Space Flight Center. "There's a case where the technology came about and found an application in a very important other scientific experiment. So I think there's a sense in which, in the field of technology dreams, people find a way to use what you produce."

Photo: NASA