On-orbit performance of Gravity Probe B orbit determination and drag-free translation control

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The Gravity Probe B (GP-B) Relativity Mission is a fundamental physics experiment to test Einstein's theory of General Relativity based on observations of gyros in a satellite in a 642 km circular polar orbit around the Earth. The GP-B satellite is designed to test two predictions of Einstein's theory, the geodetic effect and the frame-dragging effect, to an extremely high accuracy. Drag-free translation control is implemented to minimize support forces and support induced torques on the gyros. One of the four redundant gyros is used as the proof mass, and the propellant of the drag-free control system is derived from the exhaust gas boil-off from the helium dewar of the GP-B satellite. The GP-B orbit is determined primarily from the measurements of the GPS receiver onboard the satellite, and verified independently with the ground-based laser ranging data. The force biases in both the attitude and translation control system and the gyro suspension system are also estimated in the ground processing of the orbit data and compensated in the drag-free control system. This paper describes the design and implementation of the orbit determination and drag-free translation control system of the GP-B mission and shows the on-orbit performance from the launch on April 20, 2004 to the depletion of the helium on September 29, 2005.