Novel Mission and Payload Concepts for a deep-space Gravity Probe

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Recent developments in fundamental physics, cosmology and the analysis of the so called Pioneer Anomaly have sparkled new interest in precision tests of the gravitational law on all distance scales. In particular, on the scale and in the environment of the solar system, the Pioneer Anomaly presumably hints to a potential flaw in the understanding of the free fall motion of a test mass, moving outbound from the sun on a solar system escape trajectory. For an unambiguous verification of the anomalous motion and its precise characterization, the influence of non-gravitational acceleration on the test mass has to be determined and carefully discriminated from the well modeled gravitational motion in free fall to a 3D bias accuracy of better than 10^{-12} m/s^2. Several novel mission and payload concepts for such a deep space gravity probe have been proposed and elaborated by the authors recently. The first class of concepts is based on a two step process involving a radio science link of a noisy probe to an earth reference together with radio or laser ranging between the probe and formation flying free test masses, shielded or well modeled with respect to environment interaction. A second class of concepts is characterized by internal acceleration sensors or inertial sensors operated with drag-free control of the probe. Any dc-bias of acceleration must be removed or monitored to that level of accuracy. Requirements and technical concepts to realize the mission objectives will be presented.