AAE Faculty Candidate Seminar

The Spherical Gravitational Reference Sensor: *A Buoy in Spacetime*

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Abstract: The next generation of drag-free spacecraft will a) open up a new window to our universe through the currently illusive gravitational wave spectrum, b) more accurately map the time variations in the Earth's mass distribution due to our changing global climate, and c) aid in our understanding of the fundamental force of gravity. These exciting missions require more accurate determination of the position of the free floating test mass contained within the drag-free spacecraft, as well as drastic reduction of the disturbances applied to the test mass. A sphere has the advantage of being orientation invariant. This removes all requirements for test mass orientation control with respect to the spacecraft, which ultimately reduces disturbances applied to the test mass. However, the free motion of the sphere coupled with its residual irregularities (geometric, electric, magnetic, etc.) can complicate the determination of the mass center position or the angular momentum orientation. This talk will present techniques for modeling and estimating the rigid body motion of a nearly torque-free sphere in order to separate the effects of the irregularities from the desired measurement. These techniques are applied to the flight data from Gravity Probe B (GP-B) in order to estimate the spin and polhode motion of the GP-B gyroscopes to 1 degree over the course of a year, as well as the readout scale factor to 10^{-4}. Then we will examine an advanced Gravitational Reference Sensor capable of measuring the mass center location of its spherical test mass to 10^{-11} m, which will enable for future gravitational wave observatories, geodesy missions and fundamental physics tests in space. Laboratory demonstrations of key technologies for this sensor are described, focusing on a novel method for determining the mass center of a spherical test mass to ~ 100 nm, a factor of 10 improvement over any previous method.

Biography: John received his BS and MEng degrees from Cornell University in 1997 and 1998 respectively. After leaving Cornell, he joined Transnuclear, Inc. in Hawthorne, NY where he spent five years designing and testing equipment for the safe storage and transport of radioactive material. In 2003 he came to Stanford University where he completed his PhD in Aeronautics and Astronautics in December of 2008. He is currently a research associate in the Aero/Astro department at Stanford, a member of the Gravity Probe B science data analysis team, and contributes to the technology development for the Laser Interferometer Space Antenna (LISA).

John's research combines classical mechanics, dynamics, and control theory with modern measurement technologies to advance precision engineering beyond the current state of the art. This is vital for many applications that interest him, including advanced inertial instruments, fundamental physics experiments and gravitational wave detection in space, as well as precision metrology and mass property determination here on Earth.