Rieger, Samantha M. (Ph.D., Aerospace Engingeering Sciences)

Natural and Artificial Satellite Dynamics and Evolution around Near-Earth Asteroids with Solar Radiation Pressure

Thesis directed by Dr. Daniel Scheeres

Natural and artificial satellites are subject to perturbations when orbiting near-Earth asteroids. These perturbations include non-uniform gravity from the asteroid, third-body disturbances from the Sun, and solar radiation pressure. For small natural (1 cm-15 m) and artificial satellites, solar radiation pressure is the primary perturbation that will cause their orbits to go unstable. For the asteroid Bennu, the future target of the spacecraft OSIRIS-REx, the possibility of natural satellites having stable orbits around the asteroid and characterize these stable regions is investigated. It has been found that the main orbital phenomena responsible for the stability or instability of these possible natural satellites are Sun-synchronous orbits, the modified Laplace plane, and the Kozai resonance. These findings are applied to other asteroids as well as to artificial satellites.

The re-emission of solar radiation pressure through BYORP is also investigated for binary asteroid systems. Specifically, the BYORP force is combined with the Laplace plane such that BYORP expands the orbit of the binary system along the Laplace surface where the secondary increases in inclination. For obliquities from $68.875^\circ - 111.125^\circ$ the binary will eventually extend into the Laplace instability region, where the eccentricity of the orbit will increase. A subset of the instability region leads to eccentricities high enough that the secondary will impact the primary. This result inspired the development of a hypothesis of a contact-binary binary cycle described briefly in the following. YORP will increase the spin rate of a contact binary while also driving the spin-pole to an obliquity of 90°. Eventually, the contact binary will fission. The binary will subsequently become double-synchronous, thus allowing the BYORP acceleration to have secular effects on the orbit. The orbit will

then expand along the Laplace surface to the Laplace plane instability region eventually leading to an impact and the start of a new cycle with the YORP process.