ABSTRACT

THE EFFECTS OF OUTGASSING JETS ON THE ROTATION OF A COMET NUCLEUS AND ON THE TRAJECTORY OF AN ORBITING SPACECRAFT

by

Sharyl M. Byram

Chair: Daniel J. Scheeres

An outgassing jet model is presented in this thesis in support of spacecraft navigation for future missions to comets. The outgassing jet is modelled as an emission cone while the comet nucleus is modelled as a uniform density triaxial ellipsoid. The heliocentric orbit motion as well as in the strength of the outgassing jet are accounted for in the equations of motion. This model is used for predicting the rotational evolution of a comet nucleus as a result the outgassing jets' reactive torques as well as for simulation of an orbiting spacecraft's trajectory through jet passages and the estimation of the physical outgassing properties of jets from perturbations to the spacecraft's motion.

A model for the rotational evolution of a comet nucleus is presented and predicts possible levels of rotational excitation for a comet nucleus under torques produced by multiple discrete outgassing jets located on the surface. An analytical theory for the secular solution to the rotational motion of comets with an axis of symmetry is derived and used to predict rotational state changes over multiple perihelion passages. A method of characterizing the comet nucleus dynamics to predict the end state of the rotation is found from the averaged equations. Applications of these analytical results to predict the stochastic evolution of a comet nucleus rotation are outlined.

This thesis also identifies and analyzes stable Sun synchronous orbits in a Hill rotating frame which can be applied to any small body in the solar system. The stability of these orbits is due to the inclusion of solar radiation pressure effects. The stability of the orbits in terms of escaping the comet is analyzed though construction of zero-velocity curves and the use of spectral analysis. The effect of orbital perturbations from outgassing jets on the stability criterion are also considered in the stability analysis of a spacecraft in orbit about a comet. Once these orbits have been identified, the effects of a non-spherical body are explored. In addition, impulsive and finite burn control schemes to restrict a stable orbit's motion are determined, showing that it is feasible to implement a form of orbital hovering in the terminator plane of a comet.