ABSTRACT

DYNAMICS IN THE HILL PROBLEM
WITH APPLICATIONS TO SPACECRAFT MANEUVERS

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The Hill problem models the motion of two gravitationally interacting small masses perturbed by a large body. It covers several astrodynamical systems of interest, one of which is a spacecraft orbiting a planetary satellite (or planet) and perturbed by a Giant planet (or Sun).

While previous studies mainly considered a limited set of initial conditions, this dissertation investigates a larger class of motions for the Hill problem by using the notion of periapsis Poincaré maps. By reduction of the dynamics of the Hill problem to a sequence of close approaches to the primary, we can partition the phase space into periapsis or apoapsis exclusive regions and locate the regions of quasi-circular motion.

First order estimates of these maps have been derived showing that the dynamics strongly depend on the orientation of the orbits with respect to the disturbing body and indicating how they can be used to reduce the cost of orbital transfer maneuvers.

As a first application, a new class of plane change maneuvers has been derived. These transfers resemble classical bi-elliptic transfers with the apoapsis maneuver suppressed by the use of the third body forces. These transfers are shown to be preferable to classical approaches over a large range of initial conditions, realizing 70% fuel savings in the case of $\pm 180^o$ plane changes.

As a second application, escape and capture trajectories have been investigated, show-

ing the possibility of low energy direct escape from the surface of certain planetary satellites of the solar system, as well as constraints on low energy capture maneuvers. The problem of one impulse, direct escape and capture maneuvers has also been investigated, yielding an optimal result in the planar case and a practical approach otherwise. Fuel savings on the order of 17% in the case of a Europa orbiter have been obtained.

These results should be useful for mission design and planning in the case of orbital environments that can be modeled using the Hill problem.