

ABSTRACT

THE FULL TWO-BODY-PROBLEM: SIMULATION, ANALYSIS, AND APPLICATION TO THE DYNAMICS, CHARACTERISTICS, AND EVOLUTION OF BINARY ASTEROID SYSTEMS

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The Full Two-Body-Problem (F2BP) describes the dynamics of two unconstrained rigid bodies in close proximity, having arbitrary spatial distribution of mass, charge, or similar field quantity, and interacting through a mutual potential dependent on that distribution. While the F2BP has applications in areas as wide ranging as molecular dynamics to satellite formation flying, this dissertation focuses on its application to natural bodies in space with nontrivial mass distribution interacting through mutual gravitational potential, i.e. binary asteroids.

This dissertation first describes further development and implementation of methods for accurate and efficient F2BP propagation based upon a flexible method for computing the mutual potential between bodies modeled as homogenous polyhedra. Next application of these numerical tools to the study of binary asteroid (66391) 1999 KW4 is summarized. This system typifies the largest class of NEO binaries, which includes nearly half of them, characterized by a roughly oblate spheroid primary

rotating rapidly and roughly triaxial ellipsoid secondary in on-average synchronous rotation. Thus KW4's dynamics generalize to any member of that class.

Analytical formulae are developed which separately describe the effects of primary oblateness and secondary triaxial ellipsoid shape on frequencies of system motions revealed through the F2BP simulation. These formulae are useful for estimating inertia elements and highest-level internal mass distributions of bodies in any similar system, simply from standoff observation of these motion frequencies.

Finally precise dynamical simulation and analysis of the motion of test particles within the time-varying gravity field of the F2BP system is detailed. This Restricted Full-detail Three-Body-Problem encompasses exploration of three types of particle motion within a binary asteroid: 1) Orbital motion such as that for a spacecraft flying within the system about the primary, secondary, or system barycenter at large distance; 2) Motion of ejecta particles originating from the body surfaces with substantial initial surface-relative velocity; 3) Motion of particles originating from the primary surface near the equator, with no initial surface-relative velocity, but when primary spin rate is raised past the "disruption spin rate" for which material on the surface will be spun off.