Coupling of Translational and Rotational Motion Through Mutual Gravitation of Two Bodies

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The effect of mutual gravitational interactions between two bodies is investigated. During such interactions the rotational and translational motion of both bodies will become coupled, leading to shifts in their initial rotational and orbital states. We focus specifically on interactions that occur when the relative orbit between the bodies is eccentric. For this case, large changes to the relative orbit and rotation states can occur around each periapsis passage. We develop analytical estimates of the interchange between orbital and rotational angular momentum and energy that occur during each interaction. The main results are derived for the interaction of a dipole with a sphere. Extensions of the theory to interactions between two dipoles are also considered. Specific applications of the result can be made to a variety of situations, including the interactions of asteroids and comets with small ejecta, co-orbitals, or planets, and the interactions of a spacecraft with an asteroid, comet, or planet. The results of the analysis are verified with numerical integrations of interacting bodies. The numerical integrations model one of the bodies as a general mass distribution and the other as a series of connected point masses.