Orbital Resonances, Unusual Configurations and Exotic Rotation States among Planetary Satellites

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Several examples of satellite dynamics are presented where significant progress has been made in understanding a complex problem, where a long–standing problem has finally been solved, where newly discovered configurations have motivated novel descriptions or where an entirely new phenomenon has been revealed. The origin of orbital resonances is shown in the demonstration of the evolutiona of a pair oa planetary satellites through a commensurability of the mean motions by a sequence of diagrams of constant energy curves in a two–dimensional phase space, where the closed curve corresponding to the motion in each successive diagram is identified by its adiabatically conserved area. All of the major features of orbital resonance capture and evolution can be thus understood with a few simple ideas. Qualifications on the application of the theory to real resonances in the solar system are presented. The two–body resonances form a basis for the solution of the problem of origin and evolution of the three body Laplace resonance among the Galilean satellites of Jupiter. Dissipation in Io is crucial to the damping of the amplitude of the Laplace libration to its observed small value. The balance of the effects of tidal dissipation in Io to that in Jupiter leads to rather tight bounds on the rate of dissipation of tidal energy in Jupiter. Motion in the relative horseshoe orbits of Saturn's coorbital satellites is described very well by a simple expansion about circular reference orbits. The coorbitals are currently very stable, and their relative motions can be used for the determination of the masses of both satellites. Pluto and its relatively large satellite Charon form an unusual system where the relative size and proximity of Charon lead to a most probable state where both Pluto and Charon are rotating synchronously with their orbital motion. The normal tidal evolution of a satellite spin toward shychronous rotation is frustrated in the case of Saturn's satellite Hyperion where gravitational torques on the large permanent asymmetry cause it to tumble chaotically. Observations of Hyperion's lightcurve are consistent with the chaotic rotation but do not verify it with certainty.