Surfing the Interplanetary Tides

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The family of invariant manifolds around the collinear Lagrange points plays an important role in the dynamics of the solar system. Results indicate that they provide a general mechanism for the distribution and transport of material within the solar system. The focus of this paper is on the stable and unstable manifolds of L1 and L2 (the two collinear Lagrange points closest to the secondary body). The Poincaré sections of these chaotic orbits provide detailed portraits of the mean motion resonance structure of the system. These manifolds live at the boundary of the Hill stability region, forming a complex separatrix of the phase space into its stable and unstable parts. For example, from the Poincaré section of the Jupiter manifolds one can deduce the instability of the 2:1 Kirkwood gap due to Mars crossing orbits; one can deduce the stability of the Hilda group in the 3:2 resonance from the low eccentricity of the orbits. Furthermore, the manifolds of the outer planets are interconnected, thereby providing a dynamical channel between the Kuiper belt and the asteroid belt. This explains the frequently observed erratic behavior of comet orbits jumping from the Saturn family to the Jupiter family and provides a dynamical evolutionary path from comets to asteroids. The same dynamics is applicable to the asteroid belt, the Kuiper belt, planetary rings, and cometary orbits. This transport process is observed within 10,000 periods of the primary bodies and is not Arnold diffusion. This work was supported by the NASA Advanced Concepts Research Program and the Caltech Summer Undergraduate Research Fellowship Program.