Mapping The Interplanetary Superhighway

ABSTRACT
Copernicus’s heliocentric model of the Solar System consists of a series of planets in isolated, near circular orbits around the Sun. This model uses a series of coupled Sun-Planet Two Body Problems. But in the late 19th century, Poincaré discovered dynamical chaos in the Three Body Problem. This suggests that perhaps a better model is to think of the Solar System as a series of coupled Sun-Planet Three Body Problems (the third body could be a moon, asteroid, or spacecraft). In this more complex model, the planets are no longer isolated in their orbits. Instead, the entire Solar System is interconnected by a vast system of low energy trajectories living on tubular structures called invariant manifolds. These manifolds are generated by the unstable orbits in each Three Body System. The manifolds and trajectories that shadow them combine to form what we call the “Interplanetary Superhighway”. This vast transport system is what asteroids, comets, and dust particles use to move throughout the Solar System. In order to take advantage of the low energy orbits which cannot be approximated by conics, we must know where these invariant manifolds are, where they go and how to use them. Every Great Ages of Exploration has always been preceded by a technology development phase. One of the key technologies is a good set of maps. For the human exploration of space, especially in the Earth to Moon region, low energy trajectories are a critical technology which must be developed to provide inexpensive transport of materials and cargo. Elsewhere in the Solar System, robotic missions already depend critically on such trajectories. It’s just that we have not always recognized the planetary flyby trajectories are actually exploiting the invariant manifolds of unstable resonant periodic orbits in the Three Body Problem. In this seminar, we will explore these issues and consider strategies to chart the Interplanetary Superhighway both to support the exploration of space and as a scientific activity in its own right.

BIO
Martin Lo is a technologist in the JPL High Capability Computing and Modeling Group. He received his BS from Caltech (1975) and PhD from Cornell (1980) both in pure mathematics. He worked as an interplanetary mission designer at Hughes Aircraft Co. before going to JPL. There he started work on libration missions in the Three Body Problem. He is one of the early pioneers for the use of invariant manifolds for space mission design in the US. He led the team which designed the Genesis trajectory to return solar wind samples from a Halo orbit at L1 to Earth using a heteroclinic connection between L1 and L2 Halo orbits (launch 2001). In the late 1990’s while studying low energy transfers from Earth to the planets, he discovered the “Interplanetary Superhighway”, a network of low energy trajectories generated by the invariant manifolds of unstable orbits in the Three Body Problem. This concept was used to explain the dynamics of the Hiten mission, design the “Petit Grand Tour” which inspired the JIMO mission (cancelled), and design robotic lunar sample return missions (used by lunar missions like GRAIL). He also developed the concept for human servicing of deep space missions at the Lunar L1. This was a critical, enabling concept for the Human Exploration Program during its proposal phase in the early 2000’s. He is currently working on applications of invariant manifold theory to more general problems in climate, Earth science, and human health problems. He is also working on interplanetary solar sail missions using CubeSats.

Refreshments will be served at 3:30 p.m.