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SOLAR SAIL RESONANT PERIODIC ORBITS IN THE AUGMENTED EARTH-MOON QUASI-BICIRCULAR PROBLEM

Abstract

Solar sailing is a novel way of propelling space probes. It takes advantage of the acceleration produced by photons impacting upon the body, the so-called Solar Radiation Pressure (SRP). Unlike traditional thrusters, the acceleration is continuous and limited only by the durability of the sail. Although the acceleration due to the sail is much smaller than the one achieved by traditional propellers, this technology can be used for the design of, otherwise inconceivable, missions.

We are interested in understanding the dynamics of a spacecraft endowed with a solar sail in the Earth-Moon system. The most commonly used model is a modified version of the Restricted Three Body Problem (RTBP) that takes into account the effect of the SRP.

Let us stress that, any model to study such a problem needs to take into account the positions of the Earth, Moon and Sun. The problem has an unavoidable non-autonomous formulation. Considering also the gravitational effect of the Sun do not increase the complexity of the model. Moreover, there are several works in the literature reporting the role that Sun's gravity plays in the Earth-Moon system. The simplest model taking into account the gravitational effects of these three bodies is the Bicircular Problem (BCP).

The BCP is, however, a non-coherent model and highly problematic near the translunar point. For this reason we propose another basic model: The Quasi-Bicircular Problem (QBCP), a coherent version of the BCP. To construct the QBCP we first compute a real three body problem solution for the Earth, Moon and Sun that is planar and close to the bicircular. Then, the equations for the test particle are written considering this prescribed motion for the primaries. We note that the vectorfield has no closed form.

We modify the QBCP to include the effect of SRP on the sail. The resulting model depends on three parameters describing the effectivity and the orientation of the sail. Moreover, the system is a Hamiltonian periodic perturbation of the RTBP. Our goal is to understand how the simplest invariant objects, such as the periodic orbits with the same period as the Sun, change with respect the sail parameters. This is interesting because the dynamics of the model is organized from these orbits. We focus on the periodic orbits that replace the Lagrangian equilibrium points as well as the resonant orbits that come from the Lyapunov and Halo families related to the mentioned equilibria.