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COMPUTATIONAL METHODOLOGIES FOR QUASI-PERIODIC ORBITS AND INVARIANT MANIFOLD CONNECTIONS IN NON-AUTONOMOUS PROBLEMS

Abstract

Using quasi-periodic or Lissajous orbits instead of periodic solutions can increase the flexibility in trajectory design, but it can also make constructing transfer paths more complex. To address this issue, in this work we present semi-analytical and numerical techniques for systematically analyzing and refining natural connections between quasi-periodic orbits in general three or four body restricted systems.

Center, center-unstable and center-stable invariant manifolds associated to the neighbourhood of collinear libration point orbits in autonomous systems, like the RTBP, as well as non-autonomous systems, like the bicircular and quasi-bicicular, will be shown how to be computed by means of the Parameterization Method with different implementation flavours (ranging between normal form styles and graph styles depending on the solution of the so called homological equation). The radius of practical convergence, the advantages and the costs in terms of CPU time, storage and accuracy, will be analyzed attending to the size of the Taylor or Fourier-Taylor expansions which map the reduced coordinates into the physical ones, and also provide the resulting reduced vector field.

Then, the quasi-bicircular problem, which is a four body restricted non-autonomous Hamiltonian system, will be considered as baseline model to describe the periodic coherent motion and phasing conditions for transfers in or between the Earth-Moon and the Sun-Earth subsystems that contains. Connections between different libration point orbits can be accomplished by a projection-based propagation procedure and Poincaré maps.

In particular, we will focus in L_1–L_2 heteroclinic connections in the Earth-Moon subsystem perturbed by the Sun. Being the idea similar to the computation of heteroclinic connections in the RTBP, the time-dependency of the model involves a new level of difficulty, because an extra dimensionality condition is introduced. We will see how the procedure provides suitable initial guesses that by collocation methods easily converge towards continuous natural transfers connecting specific quasi-periodic orbits. By combining the methodology in different subsystems it is shown that full EML_1-EML_2-SEL_1 or EML_1-EML_2-SEL_2 chain connections can be also obtained.