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EXPLORING NEW PERIODIC ORBITS FOR THE N-BODY PROBLEM

Abstract

In recent years, a variational approach to the n-body problem has brought significant progress in the field of celestial mechanics and new possible orbits have been determined. In this case, one studies the critical points of the Lagrangian action associated to the n-body problem. In particular cases and with the use of evolutionary algorithms, one can numerically find periodic solutions of this dynamical system, once transformed into a discrete version.

The main idea is to first concentrate on the critical points, especially minima, of the action functional related to the n-body problem. Those critical points, under some assumptions, are feasible and physical solutions of the dynamical system, therefore they are periodic orbits which satisfy the differential equations. As a matter of fact, using a combination of stochastic and deterministic algorithms, one can explore the space of feasible solutions and find numerically the expression of those orbits.

Secondly, one can focus on studying the functional stability of the problem. One can map the orbits, found in the first part, as critical points and work on the stability/instability of the neighbourhoods of the found critical points. That is, given the action functional $\mathcal{A}$, one can study this new problem as a dynamical system, analysing the gradient of $\mathcal{A}$, therefore $\eta' = -\nabla\mathcal{A}(\eta)$. This method, from the one side, maps the minima found in the first part; from the other side, it also defines the basin of attraction of each minimum, as they can be derived from the algorithm studying the initial input data/starting point.

Thirdly, one can analyse the border of these defined basins of attraction. As a matter of fact, it has been proven that, when two borders are close to each other and then they separate, in the point of separation, one asymptotically tends to a critical point which is not a minimum. Using classic algorithms, such as Newton method, one can numerically find an approximation of these new critical points, which differ from the ones previously found as they are not minima.

Although this is a theoretical approach, there is a wide range of potential applications in astrodynamics, such as in mission design or placing satellite constellations in orbit.