ON THE BIFURCATION AND CONTINUATION OF PERIODIC ORBITS IN THE THREE BODY PROBLEM

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We study some new types of bifurcation of periodic orbits in the planar three body problem (TBP) consisting of a heavy body (star) and two bodies of small or negligible mass (planets). When one planet has zero mass, we have the restricted TBP. If the massive planet revolves in a circular orbit around the star, we get the circular restricted model (CRTBP) and if its orbit is elliptic, with eccentricity \( e' \), we get the elliptic model (ERTBP). Considering these models in an appropriate rotating frame, we can determine critical orbits that are generally resonant periodic orbits.

It is known in literature that periodic orbits in the ERTBP, are generated from periodic orbits of the CRTBP and are continued parametrically, by varying \( e' \), in the elliptic model (e.g. [1]). These orbits are generally symmetric, i.e. they satisfy the fundamental symmetry \( \Sigma \) of TBP. Furthermore, it has been shown that these families are continued in the general TBP, as well as the periodic orbits of CRTB, by varying the planetary masses. In this way, a net of families of periodic orbits is formed in the phase space of the general TBP [2].

In this paper we show the existence of some new families of periodic orbits in the ERTBP. Let us assume a family of orbits of the elliptic restricted problem, which bifurcates from a periodic orbit of the CRTBP of period \( 2\pi \) (see e.g. [3]). Such a family starts having either stable or unstable periodic orbits. In many cases the linear stability changes type and the corresponding periodic orbit becomes critical. We have observed that from these critical orbits, new families of asymmetric periodic orbits bifurcate and they are continued parametrically by varying the eccentricity, \( (e') \), of the massive planet.

The new families, which have been mentioned above, are continued by varying the planetary masses. So they become asymmetric families of the general planar TBP. As the planetary masses increase, these families “collide” with other asymmetric families of the general model forming new bifurcations. Following the generation and the continuation of the above mentioned families we complete the net of families of periodic orbits in the general model and we explain their origin. All these orbits correspond to the so called “exact resonances” for the planetary motion [4] and are important for the dynamics of exosolar planetary systems. Actually such orbits are attractors for the system when dissipation forces are included.

References