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ORIGINAL ARTICLE

Periodic orbits of the two fixed centers problem with a variational gravitational field

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Abstract
We prove the existence of periodic orbits of the two fixed centers problem bifurcating from the Kepler problem. We provide the analytical expressions of these periodic orbits when the mass parameter of the system is sufficiently small.

Keywords Three-body problem · Periodic orbit · Averaging theory · Variational gravitational field

1 Introduction

The non-integrability of the restricted three-body problem prevents to obtain the analytical expressions of its general solutions. The periodic orbits of this problem have extremely important applications in practical space missions. This fact has attracted a large number of mathematicians and astronomers to carry out research on the periodic behavior of the classical restricted three-body problem (see Musielak and Quarles 2014 and the references therein). The extensive research covered three categories: qualitative analysis (see Gao and Zhang 2014; Gómez and Ollé 1991; Koon et al. 2011; Musielak and Quarles 2014, and so on), analytical calculation (see Farquhar and Kamel 1973; Richardson 1980a, b), and numerical simulation (see Chenciner and Montgomery 2000; Hénon 1997; Li et al. 2018; Moore 1993; Simó 2002; Šuvakov and Dmitrašinović 2013).

For the planar circular restricted three-body problem, Zotos (2017) investigated the problem with two equivalent masses with strong gravitational field, which was controlled by the power p of gravitational potential. He revealed the great influence of the power p on the nature of orbits. For the planar rotating Kepler problem, Llibre and Paşca (2006) proved that some of the symmetric periodic orbits can be continued to the case of the restricted three-

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