Commun Nonlinear Sci Numer Simulat 94 (2021) 105550

Contents lists available at ScienceDirect

Commun Nonlinear Sci Numer Simulat

journal homepage: www.elsevier.com/locate/cnsns

Research paper

Transit regions and ejection/collision orbits in the RTBP

M. Ollé[a], O. Rodríguez[a], J. Soler[b,*]

[a] Dept. Matemàtiques, Universitat Politècnica de Catalunya, Av Diagonal 647, 08028 Barcelona, Spain
[b] Dept. Enginyeria Civil i Ambiental, Universitat Politècnica de Catalunya, Campus Nord, edifici C2, 08034 Barcelona, Spain

ARTICLE INFO

Article history:
Received 26 April 2020
Revised 23 August 2020
Accepted 24 September 2020
Available online 2 October 2020

Keywords:
Ejection/collision orbits;
Transit regions
Massive numerical simulations
Global visualization

ABSTRACT

In this paper we analyse the global behaviour of the whole set of ejection orbits in the planar circular RTBP. We consider ejection from the big or the small primary, that is we take the mass parameter μ, the mass traditionally associated with the small primary, in a range of values $\mu \in (0, 1)$ (the other primary has mass $1-\mu$). A discussion on the relation between the Lyapunov periodic orbit around the collinear equilibrium point L_1 and the ejection orbits is carried out in the range of values of the Jacobi constant such that the associated Hill regions permit only a bounded movement. In particular a chaotic infinity of heteroclinic connections between a primary and the LPO_1 are obtained. As a consequence a chaotic infinity of ejection-collision orbits is also derived. Finally, 2D plots, called colour code diagrams, allow to describe the global dynamics of the ejection orbits given a range of time. Such diagrams provide a very accurate understanding of the dynamics of the orbits under discussion.

1. Introduction

This paper considers the planar circular Restricted three-body problem (RTBP), which consists in describing the motion of a particle submitted to the gravitational forces of two point massive bodies (called primaries P_1 and P_2) that describe circular orbits around their common centre of mass. It is well known that in a suitable system of coordinates the motion of the particle is described by a system of ODE (given in Section 2). Such a system has a first integral, the so called Jacobi first integral, and we will denote by C the constant value along each solution. Moreover the system has five equilibrium points: the so called collinear ones L_i, $i=1,2,3$ and the triangular ones L_i, $i=4,5$.

Although the RTBP has been extensively studied as inspiration for many theoretical analysis and numerical simulations (even as a first approximation model in different real missions), this problem is very rich from the dynamics point of view and it is far from being well understood.

In this paper we focus on the so called ejection (collision) orbits, that is orbits described by the particle that starts ejecting from a primary. It is well known that an ejection (collision) between the particle and a primary is a singularity of the system of ODE governing the motion of the particle. So a regularization strategy is required to remove the singularities and obtain a regular system of ODE. Several approaches can be done (see [7], [9], [29] and [30]) but from the computational point of view, Levi-Civita regularization proves to be a good choice.

At this point two remarks must be done: (i) the Levi-Civita regularization is done for a given fixed value of C. (ii) It is a local regularization that removes one singularity (and the other one remains).

* Corresponding author.
E-mail addresses: merce.olle@upc.edu (M. Ollé), oscar.rodriguez@upc.edu (O. Rodríguez), jaume.soler.villanueva@upc.edu (J. Soler).

https://doi.org/10.1016/j.cnsns.2020.105550
1007-5704/