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Retrograde 1:1 mean motion resonance: a perturbative treatment

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Abstract

In the framework of restricted spatial circular three-body problem “Sun+planet+asteroid” we study the dynamics at retrograde 1:1 mean motion resonance. Retrograde motion appears clockwise when viewed from above the north ecliptic pole of the Solar System. With the use of double numerical averaging we construct evolutionary equations that describe the long-term behavior of asteroid's orbital elements. Special attention is paid to possible transitions between different types of orbits existing at retrograde 1:1 resonance.

1. Introduction

Most of objects in the Solar system move around the Sun in the anticlockwise manner when seen from above the north ecliptic pole. And only a small number of celestial bodies move in opposite direction [1,2]. Recent theoretical studies demonstrated that retrograde 1:1 MMR can predict collision of asteroid and planet in the case of co-orbital motion [3,4]. The aim of our investigation is to obtain more information about properties of this resonance.

2. Double averaged equations describing the dynamics at retrograde 1:1 mean-motion resonance

In the case of mean-motion resonance three dynamical processes can be distinguished: "fast" process corresponds to planet and asteroid motions in orbit, "semi-fast" process is variation of the resonance argument (which describes the relative position of the planet and the asteroid in their orbital motions), and, finally, "slow" process is the secular evolution of the orbit shape (characterized by the eccentricity) and orientation (it depends on the ascending node longitude, inclination and argument of pericenter).

To study the "slow" process we constructed the evolutionary equations by means of numerical averaging over the "fast" and "semi-fast" motions. As a specific feature of these evolutionary equations we should mention that their right hand sides are not uniquely defined by values of the "slow" variables in some domains of these variables. The ambiguity appears since the averaging can be done over "semi-fast" processes with different qualitative properties - in other words, it can be done over different types of resonance orbits. The consideration of this ambiguity provides us an opportunity to predict the possibility of transitions between different resonance orbits.

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