Investigation of 1:1 resonance in a rotating 4th degree and order gravitational field

Jinglang Feng[1], Ron Noomen[2], Xiyun Hou[1], Pieter Visser[2],
Jianping Yuan[3], Jingshi Tang[1], Lin Liu[1]
[1]*Nanjing University, China;* [2]*Delft University of Technology, the Netherlands;*
[3]*Northwestern Polytechnic University, China.*
123bigirl@163.com

Keyword : Asteroid, Resonance, Stability, Chaos

The commensurability (usually a ratio of simple integers) between the rotation of the primary body and the orbital motion of the surrounding spacecraft or particle is called ground-track resonance. By considering the 2nd degree and order gravitational field, orbital resonance was found to play a significant role in determining the stability of orbits [1]. With a triaxial ellipsoid model, the stability of the 1:1 mean motion resonance with a rotating asteroid was studied [2]. With a 1-DOF pendulum Hamiltonian, the widths of the resonance were found to be independent of the rotation rate and mass of the central body but strongly dependent on e and i [3]. With the 4th order truncated model, the resonant structure of some main ground-track resonances was explained of Dawn orbiting Vesta for the equatorial and circular orbits [4].

For the previous studies, the limitations are either the gravitational field which is truncated at degree and order 2 or the orbit which is restricted to a circular or polar case. In this study, the harmonic coefficients up to degree and order 4 are taken into account for studying the 1:1 resonance at different combinations of e and i, which results in a 2-DOF model. Firstly, a 1-DOF Hamiltonian is built to investigate the main properties of the 1:1 resonance. The location of EPs and their stability are solved numerically for Vesta, 1996 HW1 and Betulia. The resonance widths of the stable EPs are found numerically. Secondly, a 2-DOF Hamiltonian is introduced with the inclusion of a second resonance, which is treated as a perturbation on the 1-DOF Hamiltonian. Chaos is generated due to the overlap of the two resonances. With the aid of Poincaré section, the generation of chaos in the phase space is studied in detail by addressing the overlap process of these two resonances with arbitrary combinations of e and i. Retrograde orbits, near circular orbits and near polar orbits are found to have better stability against the perturbation of the second resonance. Finally, the maximal LCE (mLCE) of the orbits in the chaotic seas are calculated for a quantitative study and the same conclusions can be achieved.

References

[1] Hu W., Scheeres D., Numerical determination of stability regions for orbital motion in uniformly rotating second degree and order gravity fields, *Planetary and Space Science,* 52(2004)**,** 685-692.
[2] Scheeres D., Dynamics about uniformly rotating triaxial ellipsoids: Applications to asteroids, *Icarus*, 110(1994), 225-238.
[3] Olsen, Ø, Orbital resonance widths in a uniformly rotating second degree and order gravity field, *Astronomy & Astrophysics,* 449(2006)**,** 821-826.
[4] Delsate, N, Analytical and numerical study of the ground-track resonances of Dawn orbiting Vesta, *Planetary and Space Science,* 59(2011)**,** 1372-1383.