Stability Analysis of Orbital Motions around Uniformly Rotating Irregular Asteroids

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By studying periodic orbits in the body-fixed frame of uniformly rotating asteroids, stability of orbital motions of a massless particle (or spacecraft) is studied. Periodic orbits in the body-fixed frame are actually orbits in resonances with the asteroid's rotational motion in the inertial frame. The study is firstly carried out in the 2^{nd} order and 2^{nd} degree gravity field, and then generalized to the gravity field with higher order non-spherical terms. The study is divided into the planar case (i=0° or 180°) and the non-planar case (inclined orbits).

For planar prograde orbits in the inertial frame (i=0°), with the J_2 and J_{22} terms or the asteroid's rotation speed increasing, starting from the 1:1 resonance inwards and outwards, orbital motions gradually become unstable. As a result, for fast rotating asteroids with a 1:1 resonance orbit height close to its surface, generally no practical stable orbits can be found interior of the 1:1 resonance. For planar retrograde orbits in the inertial frame (i=180°), their stability is much better and does not obviously change with the increasing J_2 and J_{22} terms or the asteroid's rotation speed. However, for slowly rotators, retrograde orbits close to the asteroid's surface are also unstable due to the resonance between the precession of the orbital plane and the asteroid's rotation.

For the non-planar case, our studies show that the stability of the orbital motion is influenced by one secular resonance (the critical inclination problem). For orbits close to the surface of the asteroid, the general tendency is that retrograde orbits (90°<i<180°) have better stability properties than the prograde ones (0°<i<90°), but it's not always the case. Besides, for orbits with orbital inclinations close to the critical values (63° or 117°), they may also easily become unstable due to the joint effects between the resonances (between the orbital motion and the asteroid's rotational motion) and the secular resonance. Taking Eros as an example, example orbits escaping from the asteroid following a route with orbit inclination close to the critical values are given.