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DYNAMICS OF A TETHER CONNECTED TO AN IRREGULAR SHAPED CELESTIAL BODY

Abstract

The general problem of the dynamics of a tether connected to an irregular shaped celestial body is studied in this paper. The analysis reveals some interesting aspects of the stability of the motion and will lead to a better understanding of the dynamics of such systems. It has potential applications to asteroid deflection using tethers and development of space elevators on small planets. In most of the studies related to the use of tethers in asteroid deflection, the asteroid is usually modeled as a point mass. In this paper the effect of the asteroid shape and its rotation on the dynamics of the system is investigated. The uneven shape of the asteroid affects the system dynamics in two ways; firstly, via the offset between the tether attachment point and the centre of mass of the asteroid. The second effect is via the influence of the higher order harmonics in the gravitational potential of the irregular shaped body. In this preliminary study, the perturbation in the asteroid motion caused by the tether attachment is neglected, the tether is assumed to be massless and it is also assumed that the tether and ballast mass are within the Sphere Of Influence (SOI) of the asteroid. Therefore the influence of the sun's gravitational field on the ballast mass is neglected. Since the rotational period of asteroids are usually much smaller than their orbital period, in this study the effect of the orbital motion of the asteroid on the tether dynamics is neglected. It is shown in this paper that the offset between the tether attachment point and the centre of mass of the asteroid is a critical parameter in determining the stability of the system. For example, for the asteroid Vesta, it is shown that when the tether length is less than a critical value, the motion is not stable around the =0 equilibrium point. By increasing the tether length between this value and the second critical tether length, one obtains three equilibrium points, two of which1 are located at 0 and and are stable equilibrium points, while the third one is at some point in between these two depending on the tether length and is always unstable. The higher order potential energy harmonics can lead to significant change in the dynamics of the system only for some special initial conditions.