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DYNAMICS OF A TETHER CONNECTED TO AN IRREGULAR SHAPED CELESTIAL BODY

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The general problem of the dynamics of a tether connected to an irregular shaped celestial body is studied 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. 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. The higher order potential energy harmonics can lead to significant change in the dynamics of the system only for some special initial conditions.

I. INTRODUCTION

In this paper, dynamics of a tether connected to an irregular shaped celestial body is studied (Figure 1). In most of the studies related to the use of tethers in asteroid deflection, the asteroid is usually modelled as a point mass[1,2,3]. In this paper the effect of the asteroid shape and its rotation on the dynamics of the system is investigated

This study is of practical importance in the development of space elevators on small planets[5,6,7].

The uneven shape of the asteroid can affect the system dynamics via the offset between the tether attachment point and the centre of mass of the asteroid (represented by $\vec{r}_A$ in Figure 1), and via the influence of the higher order harmonics in the gravitational potential of the irregular shaped body on the potential energy of the system.

In this study the influence of the tether dynamics on the asteroid motion is neglected, the tether is assumed to be massless and it is assumed that the tether and ballast mass are within the Sphere Of Influence (SOI) of the asteroid. Therefore the influence of the sun gravitational field on the ballast mass is neglected.

Since the rotational period of space bodies like asteroids are usually of the order of a few hours which is much smaller than their orbital period, which is of the order of a few years, in this study the effect of the orbital motion of the asteroid on the tether dynamics is neglected.

II. DYNAMICAL MODEL

The first step is to develop a dynamical model of the system which is consisting of an asteroid connected to the ballast by a tether. Figure 1 shows the geometrical configuration of the dynamical model.

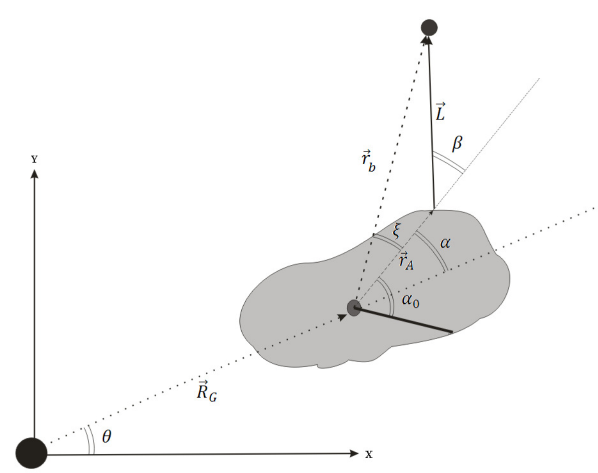

Fig. 1: Figure 1. The configuration of the body-tether-ballast system

Because of the aforementioned assumptions the only generalized coordinate of this system is β (Figure 1). $\vec{r}_A$ is the offset between the point of tether attachment and the centre of mass of the asteroid and $\vec{r}_b$ is the position vector of the ballast mass with respect to the asteroid centre of mass. α_0 is the angle between the latitude