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Global Strategy for Space Elevators (3)

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DYNAMICS OF MOON ELEVATOR

Abstract

We consider dynamics of a tethered system moving in gravitational field of two primaries, e.g., the Earth and the Moon, or a planet and its satellite, or a double asteroid system. The primaries are supposed to move about the system's center of mass along Keplerian elliptic orbits. We also assume that the moon keeps its orientation with respect to the planet and the spacecraft is anchored to the moon surface via a light tether.

The described above "Moon pendulum" has been studies since early days of space exploration. Several authors, including, J.L.Synge [1], L. Blitzer [2], V. Beletsky and E. Levin [3], and other researchers including the authors of this paper considered its different formulations before. In our work [4] we considered the possibility to maintain the orientation of the tether in the framework of the elliptic problem. The radius of the moon surface was assumed to be negligible; here we show that this parameter influences considerably the system dynamics.

The equations of motion are deduced in the framework of a restricted circular three-body problem. The system possesses several relative equilibrium configurations; the locations of these equilibria depend on system parameters, such as the radius of the moon surface and the coordinates of the anchor point of the tether. When the geometric restrictions allow it, these equilibria include the libration points of the primaries, but also a number of families of previously unknown equilibrium configurations have been found. The sufficient conditions of stability and the conditions of positive tension in the tether at the described equilibrium configurations are studied using Routh's criterion. Bifurcations of the above equilibrium configurations are considered and the respective bifurcation diagrams are constructed.

The deployment of the tethered system anchored to the moon surface is discussed; one of the options is to use two tethers.

[1] J. L. Synge, On the behaviour, according to newtonian theory, of a plumb line or pendulum attached to an artificial satellite. Proceedings of the Royal Irish Academy. Section A: Mathematical and Physical Sciences. Vol. 60, (1959), 1-6

[2] L. Blitzer, Equilibrium and stability of a pendulum in an orbiting spaceship. Am. J. Phys., 47 (3) (1979), 241–246.

[3] V.V. Beletsky, E.M. Levin, Dynamics of Space Tether Systems, Univelt, Inc., San Diego, 1993, 499.

[4] A.A. Burov, A. D. Guerman, and I.I. Kosenko, Equilibrium configurations and control of a Moon-anchored tethered system. Advances in the Astronautical Sciences, v. 146, 2013, 251-266.