Investigation of attitude dynamics for the lunar gateway

Erica Scantamburlo[1], Davide Guzzetti[2], and Marcello Romano[1]

[1]Department of Mechanical and Aerospace Engineering, Politecnico di Torino, Corso Duca degli Abruzzi, 24, 10129 Torino, Italy
[2]Department of Aerospace Engineering, Auburn University, Auburn, Alabama

One of the main targets of the Artemis program is the construction of a long-term human-tended space station in the cislunar environment for the observation of the Earth and the Sun, and for the exploration of the deep space.

Since the goals of Artemis have been revealed, a lot of attention has been dedicated to the Near Rectilinear Halo Orbits (NRHOs) originating at the Earth–Moon L_2 point. As a matter of fact, these NRHOs are solutions of the Earth–Moon circular restricted three-body problem that are characterized to be easily achievable by a spacecraft that is in a Earth orbit, and to allow a simple access to the Moon surface. Moreover, since a spacecraft that is in a NRHO can be always viewed by the Earth, communication is stable. All these properties indicate that the NRHOs originating at the L_2 point represent ideal orbits for the lunar gateway.

In the last decades a lot of research works has been dedicated to the analysis of the orbital properties and the transfers design for the lunar gateway by exploiting the NRHOs originating at the Earth–Moon L_2 point, but not so much attention has been dedicated to the attitude dynamics. For these reasons, we decide to investigate the rotational dynamics of a spacecraft while it is in a NRHO at the Earth–Moon L_2 point.

In particular, by modelling the spacecraft with a rigid body, we study the equations of motion describing the attitude dynamics by numerically analyzing the evolution of the rotational angular momentum: what we observe is that the closest passage with the Moon induces a flip of the satellite spin state, making the rotational dynamics chaotic.

Examining the dynamical system governing this problem is crucial for astrodynamics and mission design, as it enhances our understanding of the rotational dynamics characterizing NRHOs and informs the development of spacecraft attitude design in the lunar gateway.

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