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BETsMA v2.0: A friendly software for the analysis of electrodynamic tether missions in Jupiter

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1. Introduction

Space Electrodynamic Tethers (EDTs) are km-long conductors that exchange momentum and energy with a planet magnetosphere through the Lorentz force exerted by the planet's magnetic field on the tether current. Since the conducting medium (plasma) and the magnetic field of the planetary environment are essential for their operation, tether are appropriate for applications in Low Earth Orbits (LEO) and the neighborhood of giant planets like Jupiter [1, 2, 3, 4], Saturn [5], and Neptune [6]. However, the design and analysis of missions in outer planets typically requires deep knowledge on tethers modeling. The main goal of this work is spreading the use of tethers and presenting a friendly software for the mission analysis and simulation of tethers in Jupiter.

2. The software BETsMA

BETsMA is a software for the preliminary design and analysis of missions using EDTs [7]. The code was initially developed under the FP7 Space Project with acronym *BETs* (262972, European Commission). It was focussed on the analysis of deorbiting mission in LEO by bare EDTs equipped with active electron emitters [8]. After the end of the project in 2014, the original software was improved into several directions. However, it has been in the last year when the works were intensified and a second version, i.e. BETsMA v2.0, has been developed thanks to the H2020 FET-OPEN project with acronym *E.T.PACK* (828902, European Commission) [9]. BETsMA v2.0 does not only simulate deorbit maneuvers considering bare electrodynamic tethers, but also low work function tethers [10, 11], which do not requires active emitters. These two types of tethers are handled by the software in both passive (power generation) and active [12, 13] modes. Such a capability allows to analyze the performance of EDTs in a broad range of scenarios and looking for different missions goals like thrust and power generation. BETsMA v2 also includes a web interface [9] that allows to prepare and submit simulations in an easy and friendly manner (see Fig. 1).

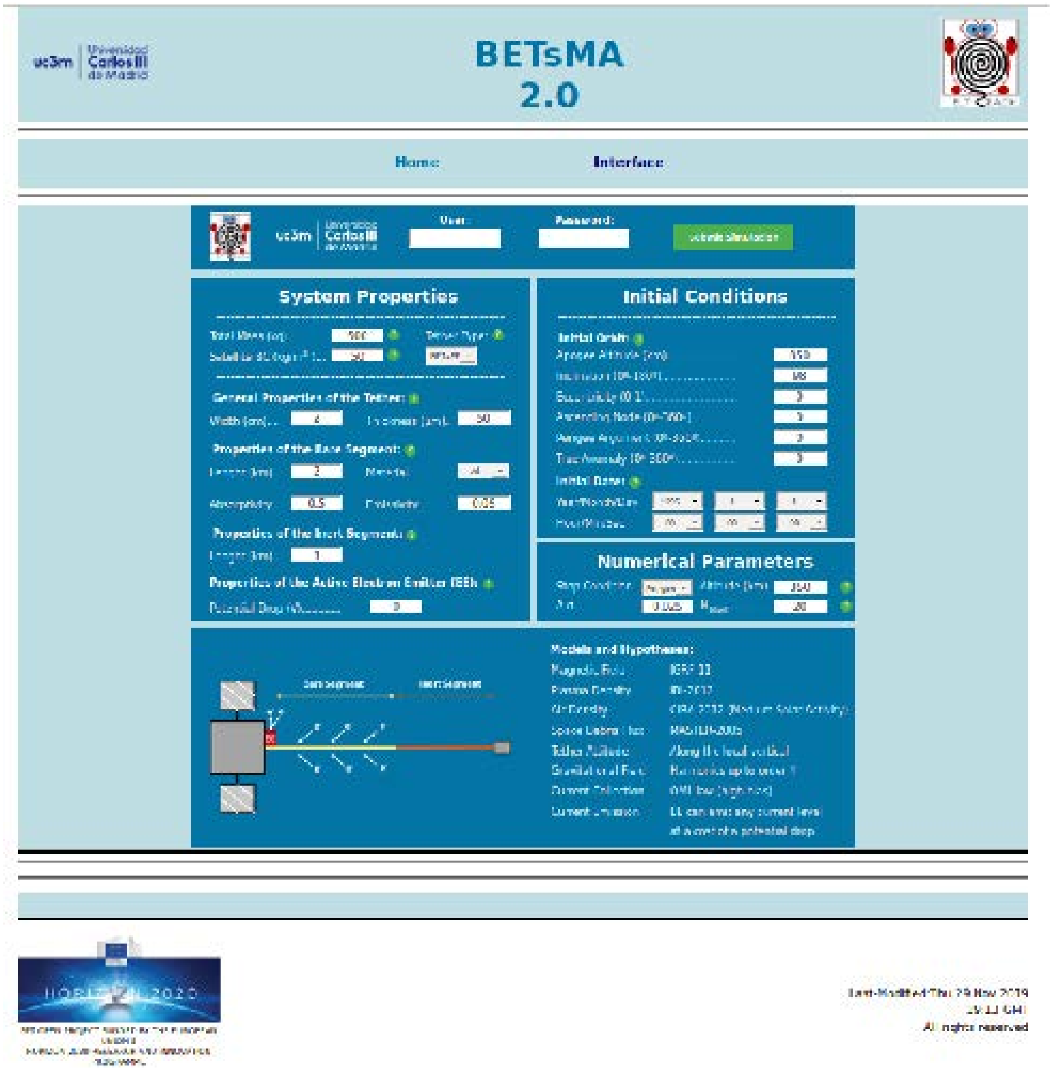

Figure 1: Web interface of BETsMA v2.0.

3. Adapting BETsMA to the Jovian environment

The most important modifications implemented in BETsMA v2.0 to address the analysis of EDT missions in Jupiter are the incorporation of models for the Jovian gravitational and magnetic [14] fields, and the plasma density [15]. The former is obviously necessary to compute the gravitational force, which is the dominant force affecting the dynamics of the tether system. Regarding the latter, i.e. the magnetic field and the plasma density, they are both essential for computing the current and voltage profiles along the tether and the Lorentz force. The thermal module that computes the tether temperature was also extended because it depends on the Sun-planet distance and the orbital period of the planet.

4. Results and conclusion

This work presents a friendly software to simulate orbital maneuvers using EDTs in the Jovian environment. Key simulations and a comparison with more simple models used in the past are shown. The results also provide insight for planing future EDT missions to explore Jupiter's system. The software may be specially useful for non tether experts, who will be able to design their own missions without having a deep knowledge on tether modeling.

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