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Energy and Momentum Analysis of the Deployment Dynamics of Nets in Space

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Abstract

In this paper, the deployment dynamics of nets in space is investigated through a combination of analysis and numerical simulations. The considered net is deployed by ejecting several corner masses and thanks to momentum and energy transfer from those to the innermost threads of the net. In this study, the net is modeled with a lumped-parameter approach, and assumed to be symmetrical, subject to symmetrical initial conditions, and initially slack. The work-energy and momentum conservation principles are employed to carry out centroidal analysis of the net, by conceptually partitioning the net into a system of corner masses and the net proper and applying the aforementioned principles to the corresponding centers of mass. The analysis provides bounds on the values that the velocity of the center of mass of the corner masses and the velocity of the center of mass of the net proper can individually attain, as well as relationships between these and different energy contributions. The analytical results allow to identify key parameters characterizing the deployment dynamics of nets in space, which include the ratio between the mass of the corner masses and the total mass, the initial linear momentum, and the direction of the initial velocity vectors. Numerical tools are employed to validate and interpret further the analytical observations. Comparison of deployment results with and without initial velocity of the net proper suggests that more complete and lasting deployment can be achieved if the corner masses alone are ejected. A sensitivity study is performed for the key parameters identified from the energy/momentum

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