Paper ID: 17549
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MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Structures - Dynamics and Microdynamics (3)

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STATIC AND DYNAMIC SIMULATION OF LARGE-DEFORMATION SOLAR SAILS

Abstract

Solar sails capture and reflect photons of the Sun to gain momentum and are propelled through space, which is a potential propulsion technology. In general, the deformation of sails under the solar radiation pressure (SRP) is minor and the solar photon is fully reflected. Thereby, solar pressure load is thought of uniform and a constant pressure load is applied as SRP in numerical simulation. However, for some space missions such as solar sails for inner solar system mission, large nonlinear deformation is unavoidable due to the higher solar pressure and the low stiffness of support structures. In these cases, the SRP is not uniform any more since the solar photon incidence angle changes seriously with the increase of deformation. SRP has a remarkable influence on static and dynamic characteristics of large-deformation solar sails, so the constant solar pressure load is not recommended in simulating. This paper proposes an effective method to apply solar pressure load on large-deformation solar sails in numerical simulation. Firstly, the effect of large nonlinear deformation on solar pressure load is discussed. Then two considerable methods of applying non-uniform solar pressure load are compared. One method uses gas flux instead of solar flux to apply pressure on solar sails, the other applies non-uniform solar pressure load by modifying pressure force vector following deformation. In the end, a method is proposed which can be easily used in the ABAQUS finite element programs. And the effectively of the method is proved in static and dynamic analysis of a 150m x 150m large-deformation solar sail for inner solar system mission. The disturbing torque due to non-uniform pressure load is also obtained, which is a significant reference for solar sail designs.