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# A TORUS-SHAPED SOLAR SAIL ACCELERATED VIA THERMAL DESORPTION OF COATING

**Abstract**

The concept of using inflatables structures for a spacecraft has been extensively discussed during the past six decades. Inflatable structures possess special properties such as low weight and minimal stowage volume that make them suitable for solar sails. We consider a deployment and dynamics of a torus-shaped sail, which can be unfurled using an inflatable torus-shaped rim structure. The torus-shaped sail consists of a thin reflective membrane attached to an inflatable torus-shaped rim. The sail's deployment from its stowed configuration is initiated by introducing inflation pressure into the toroidal rim with a round flat membrane coated by special heat-sensitive materials that undergo the transition from the solid state phase into the gas phase [1]. The membrane is kept open and flat by the distribution of the dynamic pressure of the gas in the toroidal rim. The deployment and acceleration of the solar sail could be split into three steps: in the first step, at a particular heliocentric distance a torus-shaped solar sail is deployed by the gas inflated into the structure and the membrane, which is coated with materials that undergo thermal desorption (TD) at a specific temperature, is extended to a final flat shape; in the second step, the membrane coat undergoes TD as a result of heating by solar radiation and the inflation deployed torus-shaped solar sail is accelerated via TD of coating [2]; in the third step, when the TD process ends, the sail utilizes thrust from the Sun and escapes the Solar System through the conventional acceleration due to solar radiation pressure (SRP). We determine the required structural strength of the inflatable torus to support the flat surface of a circular membrane of a solar sail and study the deflection of the flat membrane due to accelerations initiated by TD and SRP using the equation of membrane. While the governing equation for gas in an inflated torus is assumed to be the equation for a uniform and inviscid ideal fluid. Within such approach we investigate the effects of both the enclosed gas pressure and structure stiffness on the mode shapes of the inflated torus and the stability of the torus-shaped solar sail. It is demonstrated that the effect of the enclosed gas must be considered in the dynamic analysis of the inflatable torus with the membrane.

References

[1] R. Ya. Kezerashvili, Acta Astronautica 117, 231–237 (2015). [2] E. Ancona and R. Ya. Kezerashvili,.ASR 63 (2019).