

IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)

Space Structures II - Development and Verification (Deployable and Dimensionally Stable Structures) (2)

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DEPLOYMENT AND STRETCHING OF THE CIRCULAR SOLAR SAIL BY A
SUPERCONDUCTING CURRENT LOOP**Abstract**

We present a new idea of the deployment and stretching of the circular solar sail attached to the superconducting current loop. It is predicted that a superconducting current loop can deploy and stretch the circular solar sail membrane. The magnetic field induced by the superconducting current loop and elastic properties of a circular solar sail membrane and wire loop are analyzed within a strict mathematical approach based on classical electrodynamics and the theory of elasticity. The formulas for the wire and sail membrane stresses and strains caused by the current in the superconducting wire are derived. The analytical expressions can be applied to a wide range of solar sail sizes. Numerical calculations for the sail of radius of 10 to 50 m attached to Nb-Ti superconducting wire with the cross-section radius of 0.5 mm to 10 mm made of Be, Aluminized Mylar, Kapton, and CPI membrane of the thickness of 40 nm, 30-50 nm, 2.5 μm and 3.5 μm , respectively, are presented. Calculations were performed for the engineering current densities of 500 A/mm² to 1000 A/mm².

Our study reveals that if the sail membrane is coated by heat-sensitive materials that undergo thermal desorption from a solid to a gas phase [1,2] the sail can be accelerated to the cruise velocity up to 20-40 AU/year. The vicinity of the Kuiper Belt Objects can be reached in less than 1-3 years, while the Sun's gravity focus can be reached in 13-25 years [3]. Our results propose the design and construction of the circular-shaped solar sail that can be deployed and stretched by the attached superconducting wire.

References

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