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

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DYNAMIC DEPLOYMENT AND ATTITUDE CONTROL MOTION OF SPINNING SOLAR SAIL "IKAROS"

Abstract

In this paper, the deployment motion and attitude control motion of spinning solar sail "IKAROS" is analyzed by multi-particle model. The model is adjusted by the comparison with the flight data. The Japan Aerospace Exploration Agency (JAXA) makes the world's first solar power sail demonstration of photon propulsion and thin film solar power generation during its interplanetary cruise. This spacecraft is named IKAROS. The demonstrator deploys and spans a membrane of 20m in diameter using the spin centrifugal force of four tip masses. The sail spacecraft steers its orientation in time-to-time to demonstrate photon acceleration in accordance with the guidance strategy. This is the first actual solar sail flying an interplanetary voyage. Several kinds of deployment methods have been investigated in the world, and JAXA has studied the spinning type. The membrane is deployed, and kept flat, by its spinning motion. This deployment method can be realized with simpler and lighter mechanisms than conventional mast or boom types as it does not require rigid structural elements. The proposed deployment method consists of two stages. In the folded configuration, each quarter of the membrane is line-shaped and rolled up around the main body. In the first stage, it is extracted like a Yo-Yo despinner, and form a cross shape. The shape is maintained by rotation guides. In the second stage, the rotation guides are released and each quarter of the membrane expands to form a square shape. If the first stage of the deployment is performed dynamically, the membrane will be twisted around the main body just after the deployment. Therefore, the first stage of the deployment needs to be performed statically. On the other hand, the

second stage of the deployment can be performed dynamically. The membrane deployment was performed successfully. However the preflight simulation data of the second stage deployment does not correspond with the flight data perfectly. In this paper, the multi-particle model is modified by comparison with these results and the deployment motion is analyzed precisely. After the membrane deployment, the maneuver of the attitude control is performed by the gas jet thrusters mounted on the main body for the orbit control using the solar sail. This attitude motion is complicated because the membrane and main body are spinning. This paper presents the analysis of the steering motion using the modified model and the comparison with the flight data.