Paper ID: 11075
oral
student

MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Structures II - Development and Verification (Deployable and Dimensionally Stable Structures) (2)

Author: Mr. Yoshikazu Chishiki
The University of TOKYO, Graduate school, Japan, chishiki.yoshikazu@jaxa.jp

Dr. Yoji Shirasawa
Japan Aerospace Exploration Agency (JAXA), Japan, shirasawa.yoji@jaxa.jp
Dr. Osamu Mori
Japan Aerospace Exploration Agency (JAXA), Japan, mori.osamu@isas.jaxa.jp
Dr. Hirotaka Sawada
Japan Aerospace Exploration Agency (JAXA), Japan, sawada.hirotaka@jaxa.jp
Dr. Junichiro Kawaguchi
Japan Aerospace Exploration Agency (JAXA), Japan, Kawaguchi.Junichiro@jaxa.jp

ESTIMATION OF THE MEMBRANE SHAPE OF IKAROS BASED ON EXPERIMENT AND IMAGE BRIGHTNESS ANALYSIS

Abstract

In May 2010, IKAROS (Interplanetary Kite-craft Accelerated by Radiation Of the Sun) was launched by Japan Aerospace Exploration Agency (JAXA). It is the world's first solar sail demonstration spacecraft. In this research, membrane shape of IKAROS is clarified by using some pictures taken in the space with cameras separated from the main body. The result is compared with the shape estimated from attitude motion and orbit motion. Moreover, the reason of the deformation is verified structurally and experimentally. Solar sail is a form of spacecraft propulsion using the solar radiation pressure to alter a spacecraft's trajectory and control its attitude. IKAROS has 14-m-square solar sail and succeeded in spreading the sail and taking pictures of it for the first time in the world. Looking carefully at the pictures, the sail shape seems unlevel contrary to its design. Since the direction and the size of the solar radiation pressure is determined by the normal vector of the surface, the sail shape largely affects the sail's performance. So, it is very important to clarify the shape not sensuously but numerically. It is difficult to estimate the shape of the IKAROS sail in the space with structural analysis. There are two reasons. One is that the sail is stretched by the centrifugal force of spinning. The other is that there are some mission equipments on the membrane like as thin-film solar cells and liquid crystal panels. So, analysis with image is very effective, and the best way is to focus on the reflected light on the sail, considering the characteristics of the cameras. The reflection model, especially in the space, is composed of two elements, diffuse reflection and specular reflection. Diffuse reflection spreads isotropically and its strength is determined by the angle between the illuminant direction and the surface normal. On the other hand, specular reflection exists only around the specular direction. Relative strength between these two depends on the surface characteristics. However, since there are many wrinkles and scuffs on the sail, the characteristics of the surface have a possibility to change. So, some ground experiments are conducted to know the detail characteristics. As above, we make a presentation about the approach for analyzing the pictures to obtain the shape of IKAROS sail, the comparison of the result with flight data, and the verification of the reason of the deformation.