

## **IKAROS and Solar Power Sail-craft Missions for Outer Planetary Region Exploration**

*Osamu Mori, JAXA; Takanao Saiki, JAXA; Yoji Shirasawa, JAXA; Hideki Kato, JAXA; Yuichi Tsuda, JAXA; Ralf Boden, The University of Tokyo; Jun Matsumoto, The University of Tokyo; Toshihiro Chujo, The University of Tokyo; Shota Kikuchi, The University of Tokyo; Yusuke Oki, The University of Tokyo; Kosuke Akatsuka, The University of Tokyo; Shuji Matsuura, JAXA; Hajime Yano, JAXA; Ryosuke Nakamura, AIST; Yoko Kebukawa, Yokohama National University; Jun Aoki, Osaka University; Junichiro Kawaguchi, JAXA;*

A Solar Sail is a space yacht that uses the pressure of sunlight on a large membrane for propulsion. It thus can move forward without consuming propellant as long as it can harness enough energy from sunlight. A Solar Power Sail is an original Japanese concept in which electrical power is additionally generated by thin-film solar cells on the sail membrane. This power can be used for electrical propulsion to supplement the thrust from photon pressure.

The Japan Aerospace Exploration Agency (JAXA) achieved the world's first demonstration of a solar power sail on the IKAROS during interplanetary cruise. IKAROS was launched in May 2010 and performed following missions to achieve full success criteria in seven months.

- (1) Deployment of Large Membrane Sail
- (2) Generating Electricity by Thin Film Solar Cells
- (3) Demonstrating Photon Propulsion
- (4) Demonstrating Guidance, Navigation Control Skills for Solar Sail Propulsion

A solar power sail-craft can not only use a solar sail to save propellant but can also generate electrical power using a vast area of thin-film solar cells on the sail membrane, even at large distances from the Sun. By using the electrical power to operate ultra-high specific impulse ion engines, a hybrid propulsion system can be realized. A solar power sail is applicable to missions to the outer planetary region. As a follow-on to IKAROS, we propose the world's first Jovian Trojan exploration using the solar power sail.

The spacecraft will make a first round trip to the Trojan asteroid using Earth and Jupiter gravity assist. The operation around the asteroid is expected to last more than 1 year. The spacecraft will maintain a certain altitude with chemical thrusters and take images for global mapping of the asteroid and create a three-dimensional model of the asteroid. Subsequently, the daughter spacecraft will be released to perform landing and sample collection for in-situ analysis. As an extra sample return mission, the daughter spacecraft will pass the samples by rendezvous with the mother spacecraft.

This innovative solar power sail craft will carry the following demonstrations of new technologies that will be required for future solar system exploration. In addition, the mission has several new innovative first-class planetary science and space physics objectives. The spacecraft will perform infrared astronomy observations together with dust and Gamma-ray burst detections during cruise, and will visit the Trojan asteroids.

In this paper, the result of IKAROS mission is introduced and the outline of solar power sail mission toward Jovian Trojan asteroid is presented.