**INVESTIGATION OF THE SOLAR SYSTEM DISK STRUCTURE DURING THE CRUISING PHASE OF THE SOLAR POWER SAIL MISSION.** T. Iwata[1]*, T. Okada[1], S. Matsuura[2], K. Tsumura[3], H. Yano[1], T. Hirai[4], A. Matsuoka[1], R. Nomura[5], D. Yonetoku[6], T. Mihara[7], Y. Kebukawa[8], M. ito[9], M. Yoshikawa[1], J. Matsumoto[1], T. Chujo[1], and O. Mori[1], [1]Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency (3-1-1 Yoshinodai, Chuo-ku, Sagamihara, Kanagawa 252-5210, Japan; *iwata.takahiro@jaxa.jp), [2]Kwansei Gakuin University, [3]Tohoku University, [4]Chiba Institute of Technology, [5]Japan Aerospace Exploration Agency, [6]Kanazawa University, [7]RIKEN: Institute of Physical and Chemical Research, [8]Yokohama National University, [9]Kochi Institute for Core Sample research, Japan Agency for Marine-Earth Science and Technology.

**Introduction:** In the last and the next decades, Japan's solar-system explorations are expanding their targets from the near earth to the deep space regions. The Hayabusa spacecraft explored the S-type near-earth asteroid 25143 Itokawa and brought its samples. The Hayabusa2 spacecraft was launched in 2014 and will start to explore the C-type asteroid 162173 Ryugu in 2018. The target asteroid is also one of near-earth asteroids, however, C-type asteroids have generally more primitive materials, and originate in the outer region of the main-belt asteroids [1]. Hayabusa2 mission is expected to shed light on the status of water, such as, the degree of aqueous alteration and the stage of thermal metamorphism on the C-type asteroid [2]. The Mars Moon Exploration (MMX) spacecraft is under development to explore Phobos and Deimos. These Martian moons are under the arguments, which are the giant-impact origin or captured-asteroid origin [3]. By elucidating the evolution of Martian system, we will study the origin and transportation of organic materials in the early stage of our solar-system. DESTINY+ is also under development to explore 3200 Phaethon that is the parent body of the Geminids meteor shower. The observations will provide information about the status where interplanetary or interstellar dusts are supplied to the earth.

The Solar Power Sail (OKEANOS: The Outsized Kite-craft for Exploration and Astronautics in the Outer Solar System) is a spacecraft powered by hybrid propulsion of solar photon acceleration and ion engines currently under the selection process for the future middle-class strategic space science mission by the Institute of Space and Astronautical Science, JAXA [4]. While its primary goal is an engineering verification of outer planetary region exploration technologies, its main scientific investigation aims to the first ever in-situ study of a Jupiter Trojan asteroid in the L4 or L5 region by rendezvous and landing [5]. In addition, thanks to its large heliocentric distance up to 5.2 AU and long cruising phase from its launch to the Jupiter swing-by, this mission will provide a unique opportunity to continuously explore our solar-system at 1 to 5.2 AU for benchmark studies of planetary system formation and evolution.

**Mission Outline:** The current deign of the Solar Power Sail spacecraft has a large sail membrane of about 40 m x 40 m to be accelerated by solar photon pressure [4]. Its sail membrane equips thin-film solar cells which generate enough electric power to operate electric propulsion or to fully conduct scientific investigations in the outer planet region up to 5 kW levels, without employing nuclear technology. These technologies follow and advance the heritage of the IKAROS spacecraft which has demonstrated the first interplanetary solar sail technology and observed interplanetary dust and gamma-ray bursts since 2010 [6, 7, 8].

Mission profiles of the Solar Power Sail were examined by assuming the launch years as 2026 in the Phase-A study. After the launch by H-IIA rocket in 2026, the spacecraft will execute initial check-out, and then, the cruising-phase science observations will be started. The spacecraft will be accelerated by the Earth swing-by in 2027 and accelerated by the Jupiter swing-by in 2030. Ion engines will be in full operation to change orbit after the Jupiter swing-by. Therefore, the main cruising-phase science observations will be finished in this phase to keep enough electric power for ion engines operations. Thus, in the case of the launch in 2026, the main cruising phase is for four years from 2026 to 2030. The probe will approach and rendezvous with the Trojan asteroids in 2039, then it will start remote-sensing and in-situ observations of selected Trojan asteroids.

**Scientific Objectives:** Zodiacal light observed at visible and near-infrared wavelengths is thought to be sunlight scattered by interplanetary dust or micrometeoroids. The two-dimensional distribution of zodiacal light reflects the three-dimensional structure of interplanetary dust [9]. However, it is still controversial whether the dust originates from asteroids or comets. Therefore, the comparison of the radial distribution of zodiacal light and the in-situ dust observation will help clarify the distribution and components of solid particles in our solar system. These results are expected to provide precise distribution of the dust in our solar-system discs...

The temperature of the solar wind, which depends on the heliocentric distance, has been observed to be greater than that predicted by the adiabatic model [10]. Therefore, the existence of heating processes, such as plasma turbulence or magnetic reconnection, could be predicted. The observation of the magnetic field by the devices separated in the scale of the membrane of the Solar Power Sail provides the resolution of the plasma turbulence on the electron scale. Thus the intermittent observation of the magnetic field between the Earth and Jupiter would determine the heating mechanism of the solar wind. The synergy of the magnetic field and dust observation may show the interaction between interplanetary dust and solar wind. By analyzing the environments on the dust surface, the chemical evolutions of molecules caused by solar wind and cosmic radiation can be investigated.

Table 1 Instruments for cruising-phase sciences of the Solar Power Sail

| instruments | characteristics | sensor position |
|---|---|---|
| EXZIT | 10cm-diameter telescope for 0.4 to 1.7 micro-meters | on the +z panel on lower deck |
| ALDN-2 | 20 sets of PVDF dust sensors | on the membrane |
| MGF-2 | 2 sets of fluxgate magnetometer | at the tips of the membrane |
| GAP-2 | Gamma-ray polarimeter | on the +z panel on lower deck |

**Scientific Instruments:** Candidates of scientific instruments for the cruising-phase of the Solar Power Sail spacecraft are listed in Table 1.

**EXZIT:** The Exo-zodiacal Infrared Telescope (EXZIT) is a visible-light and near-infrared offset Gregorian telescope with a 10cm-diameter aperture [11]. It will observe from 0.4 to 1.7 micro-meters in wavelength. EXZIT, with the mass of about 12kg, will be mounted on the +z panel of the lower deck of the spacecraft. The all-aluminum telescope and the Linear Variable Filter (LVF) are based on the Cosmic Infrared Background Experiment (CIBER)-2 [12]. EXZIT will observe the zodiacal light from the launch to the main asteroid belt, and then search for the extragalactic background light until it approaches to Jupiter.

**ALDN-2:** The Arrayed Large-area Dust Detectors in Interplanetary Space (ALDN)-2 detects interplanetary dust using the Polyvinylidene Fluoride (PVDF) dust sensors installed on the membrane. It is an improved model of ALADDIN that was installed on IKAROS and observed interplanetary dust between the Earth and Venus [5]. Twenty sensors of ALDN-2 with the total mass of about 1kg will be mounted on the membrane, and the electronics with the mass of about 0.3kg will be equipped in the lower deck. ALDN-2 will detect interplanetary dust between the Earth and Jupiter and compare the distribution with the results of EXZIT. It will observe the dust around the Trojan asteroids after it approaches to the Trojan. Another type of sensor is under investigating for effective synergetic observations with MGF-2.

**MGF-2:** The Magnetic Field Experiment (MGF)-2 is an improved fluxgate magnetometer model of the MGF on the Exploration of Energization and Radiation in Geospace (ERG) that was injected into the orbit on the Earth in 2016, which based on MGF-I on Bepi-Colombo MMO Satellite [13]. Two devices with each mass of about 3kg will be installed in the tip of the framework of the membrane to provide the resolution on the electron scale for interplanetary plasma turbulence by the separation of about 40m. MGF-2 will measure the interplanetary plasma in the cruising-phase, and it will measure the magnetic fields around the Trojan asteroids after it approaches there.

**GAP-2:** The Gamma-ray Burst Polarimeter (GAP)-2 is an improved model of GAP on IKAROS [6]. It consists of a sensor on the +z panel of the lower deck and an electronics in the lower deck. The total mass is about 5kg. The main targets of GAP-2 are gamma-ray burst phenomena to clarify the emission mechanism and localization of gravitational wave counterpart with the inter planetary network method. We are investigating the possibilities to detect gamma-rays and particles from the solar-system shocks.

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