HELIOCENTRIC VARIATION OF COSMIC DUST FLUX MEASURED BY THE IKAROS-ALADDIN BETWEEN THE EARTH AND VENUS. H. Yano[1,2], T. Hirai[1,3], C. Okamoto[2], M. Fujii[4], M. Tanaka[5], N. Moriyama[6], M. Burchell[7], and IKAROS-ALADDIN Team[1,2], [1]JAXA/ISAS, (3-1-1 Yoshinodai, Chuo-ku, Sagamihara, Kanagawa 252-5210, JAPAN, e-mail: yano.hajime@jaxa.jp), [2] JAXA/JSPEC, [3]Graduate University for Advanced Studies, [4]FAM Science, [5]Tokai University, [6]Kureha, Co., Ltd., [7]University of Kent at Canterbury.

IKAROS Mission Status: Japan's solar sail technology demonstration spacecraft IKAROS (Interplanetary Kite-craft Accelerated by the Radiation of the Sun) was successfully operated longer than 1.5 years, well beyond its nominal operational period of 3-6 months, in deep space between the Earth and Venus orbits from its launch in May of 2010 until its first hibernation operation at the end of 2011. The spacecraft, which remained few attitude control fuels, was awaken in September of 2012 and checked its health condition including science detectors and has been put into the second hibernation period in October.

ALADDIN System: On the anti-Sun face of its 7.5-micron thick polyimide sail membrane, IKAROS carries a large-area but still light-weight dust detector made of 8 channels of 9-20 micron-thick PVDF were attached [1, 2, 3]. This detector is called the Arrayed Large-Area Dust Detectors in INterplanetray Space (ALADDIN) and has effective detection area of 0.54 m^2. These PDVF sensors are capable of detecting hypervelocity impacts of micrometeoroids at >~10^-12 g, according to ground calibration impact experiments. A total mass of the sensor array is 37 g excluding flexible harness on the sail and the electronic box connected to the interface unit inside the main spacecraft is weighed 210 g [4]. Such as a light-weight system required to simplify electronic unit which filters electronic, thermal and vibration noises and records time, peak hold value above its threshold, and relaxation duration of each impact signal. The read-out time and sampling rate are set to be negligible levels for scientifically valuable signal acquisition.

Objectives: The first objective of ALADDIN is to test this large PVDF array system on thin sail membrane for cosmic dust impact detection in the interplanetary cruising operation, in order to prepare for a larger sail mission to outer planetary region such as Jupiter and Saturn in the near future. The second objective is to measure heliocentric flux variance of cosmic dust inside the orbit of the Earth (~1.0 AU) down to the vicinity of Venus (~0.7 AU) continuously, and opportunistic detections of possible fine dust structures (flux anisotropy) such as circumsolar dust rings near the Earth and Venus and opportunistic crossing of cometary dust trails [5, 6].

Flight Operation and Calibrations: ALADDIN started its nominal measurement on June 30th of 2010 and the last down linked data so far came in October 2011. During the 16-month cruising between the Earth's orbit and Venus' orbit (i.e., 1.0~0.7 AU of heliocentric distance) in 1.5 revolutions, ALADDIN detected >2800 dust impacts, after various screening processes of noise signals (Table 1). The PVDF sensor was pre-baked during the manufacturing processes to minimize sensitivity degradation by high temperature as a function of the heliocentric distance and ground calibrations by various hypervelocity impact facilities are conducted with the thermally treated flight spares accordingly.

Flux Measurements: At the best, impact flux was separated by a 24-hour bin, thus enabling to discuss heliocentric dependency of the flux variation around >10^-12 g mass range in the finest detail among any previous spacecraft such as Helios-1/2 in 1970's and Galileo in 1990's in similar heliocentric distances [7].

The ALADDIN dust flux in 2010-2011 shows continuous raising of the flux about an order of magnitude between the Earth and Venus orbits, for both inward cruising to its perihelion and outward cruising to its aphelion; it is also generally consistent with flux trends of Helios in 1970's and Galileo in 1990's although temporal and spatial resolutions of the IKAROS results are much finer than these previous spacecraft [7,8].

It is evident that there are some fine structures in different locations and epochal variations at the similar heliocentric distance but different orbital position (Fig. 1). This may imply the infrared dust enhancement along the circumsolar dust ring of the Earth's orbit including "dust blob" on the trailing edge (Fig. 2). Some of close passages of known cometary dust trails are also investigated and continued further. A possible flux enhancement near the predicted Venus' circumsolar dust ring is also under the investigation.

References: [1] Yano, H. and Solar Power Sail Dust Detector Team (2008) *Abst. the 37th COSPAR*, Montreal, Canada. [2] Yano, H., Yoshida, F., Takato, N., Kokubo, E. and the JAXA Jupiter and Trojans Exploration WG Preparation Team (2009) *Abst. ISTS2009*, ISTS2009-k-47, Tsukuba, Japan. [3] Yano, H., Tanaka, M., Okamoto, C. and IKAROS-ALADDIN Team (2010) *Abst. the 38th COSPAR*, Bremen, Germany. [4] Yano, H., et al. (2011) *Abst. the 42nd LPSC*, Houston, TX, U.S.A. [5] Yano, H., et al. (2011) *Abstr. Book AOGS2011,* ST05-PS12-A018, Taipei, Taiwan. [6] Yano, H., et al. (2012) *Abst. the 43rd LPSC*, Houston, TX, U.S.A. [7] Yano, H., et al. (2012) *Abst. the ACM2012,* Niigata, Japan. [8] Yano, H., et al. (2012) *Abst. the 39th COSPAR,* Bangalore, India.

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Table 1: Impact counts on 20-micron PVDF sensors of ALADDIN during the first round trip in 2010-2011

	inbound	outbound
Period	2010.06.30~12.03	2010.12.15~2011.05.31
Helio-centric Distance	1.07~0.72 AU (0.97~0.90 missing)	0.72~1.08 AU
Impact Signals	969	1260

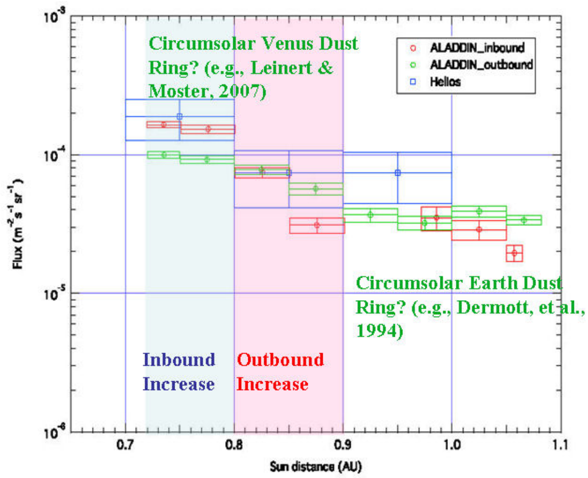

Fig.1 Round trip measurement of ALADDIN impact flux variation between the Earth and Venus, compared with the Helios results.

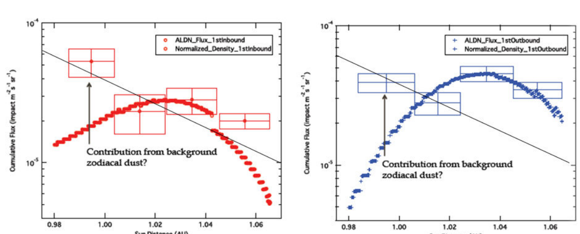

Fig.2 Direct comparison between the converted COBE model of cross section density and the ALADDIN impact flux for the inbound and outbound trajectories near the Earth's heliocentric orbit.