

Observation of cosmic dust with a deployable film type dust sensor mounted on a nanosatellite: ASTERISC project

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Optical observations of the zodiacal cloud and in-situ observations by spacecrafts show that dust particles are widely distributed from the inner region of the solar system to the Plutonian orbit. Dust particles are thought to be a ubiquitous constituent of planetary systems and have contributed to the origin and evolution of the planetary systems in various ways. In the early stage of our solar system, dust particles agglomerated into planetesimals, and planetesimals coalesced together to form planets. Afterward, dust would have been released from comets and asteroids which were remnants of planetesimals. The released dust particles have distributed in interplanetary space as interplanetary dust. In some cases, interplanetary dust would have accreted onto other planets. Actually, interplanetary dust is thought to have contributed significantly to the mass inventory of extraterrestrial matter on the earth. Interplanetary dust has also been proposed as an important carrier of organic compounds to the early earth and could have made a significant contribution to the origins of life.

Here, we focus on β -meteoroids. Dust particles known as beta-meteoroids are blown away from the sun by the outward force of solar radiation pressure and finally ejected from the solar system entirely in unbound orbits. β -meteoroids are one of the main carriers that constantly transport planetary materials (containing possibly organics and volatiles) outward within the solar system and out of the solar system. To better understand the evolution of the interplanetary dust cloud, the material transport within the solar system, and furthermore, the supply of the materials into interstellar space, we need to know in detail the flux of β -meteoroids. However, its nature has not been fully resolved yet, due to some observational difficulties. First, a small spatial density of β -meteoroids requires a sensor with a large sensitive area. Second, it is impossible for the existing dust analyzer to observe the direction of the sun from which β -meteoroids come (The impact ionization-based dust analyzer, which has been often used as the instrument of spacecraft, cannot work due to the photoelectric effect caused by the sunlight).

In this study, we have developed a new type of dust sensor system to observe cosmic dust. The sensor is a thin polyimide film attached with small piezoelectric sensors to pick up elastic waves induced by dust impacts. Specifically, (i) elastic wave generated by a collision of a dust particle onto a polyimide film are converted into electric signals by a group of piezoelectric sensors arranged on the film surface, (ii) the signals are fed by cables to an electronics circuit and (iii) the signal waveforms are sampled by A/D converter and stored in a memory when it is determined to be a true event. By simultaneously measuring with multiple piezoelectric sensors placed evenly spaced apart on the film, the true signal is distinguished from noise with reference to the arrival time, amplitude, and duration of the signal acquired by each piezoelectric sensor.

Since the entire film operates as a dust sensor, a large area sensor can be easily realized by increasing the area of the film. In addition, because the system detects only solid particles impacting onto the film and are not affected by the sunlight, it can turn the sensor to the direction of the sun, which is a requisite for observation of β -meteoroids.

We are now developing our second 3U CubeSat “ASTERISC (Advanced Satellite Toward Exploration of dust enviRonment with In-Situ Cosmic dust sensor)” to monitor interplanetary dust and artificial debris particles in a low geocentric orbit. A deployable thin-film dust sensor system will be mounted on the CubeSat. It enables a continuous real-time observation of interplanetary dust and artificial space debris particles in a low geocentric orbit. This satellite is scheduled to be launched in FY2021 by the JAXA Epsilon rocket.

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