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Circum-Martian Dust Monitor of Martian Moons Exploration (MMX) mission

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Abstract

In order to determine whether Martian dust belts (ring or torus) actually exist and, if so, to determine the characteristics of the dust, we are developing a Circum-Martian Dust Monitor (CMDM) to be aboard the Martian Moons Exploration (MMX) project. JAXA plans to launch the MMX spacecraft in 2024 to investigate Phobos and Deimos, and to have samples returned to Earth. The CMDM is now under development to detect dust particles around the Mars which has been theoretically predicted yet undiscovered for a long time. The CMDM has been studied to have a sensitive area of 1m^2 to survey the dust particles down to the background interplanetary dust particle flux level. During the cruising phase of the MMX from the Earth to the Mars, the CMDM may also observe large-sized dust particles as remained in cometary trails in which the MMX may overpass.

1. Introduction

Since the existence of dust particles orbiting around Mars was suggested by Soter [2], and there have since been many theoretical predictions and many experimental attempts to discover Martian dust rings, however, it has not been discovered yet. Although these are important events to understand mass transfer in the solar system, their spatial density is small, and therefore *in-situ* survey down to background interplanetary dust particle flux requires a sensor with a very large sensitive area (> 1 m^2) is required. However, it is often difficult to mount such a large-area dust sensor from the viewpoint of resource requirements to typical spacecraft systems. We are developing a dust sensor system named Circum-Martian Dust Monitor (CMDM) which is adopted as a science payload of the Martian Moons Exploration (MMX) spacecraft as a middle class mission of the Japanese Aerospace Exploration Agency (JAXA) [3]. The MMX is planned to be launched in 2024 in order to investigate Phobos and Deimos, and to have samples returned to Earth [3]. In this paper, we describe the CMDM and its development, an orbiting dust detector that we propose for the Martian Moons Exploration (MMX) project being planned.

2. Sensor and Instrumentation

Figure 1 shows a conceptual drawing of CMDM sensor. It is a Momentum sensor and has 1m^2 sensitive area for dust detection [1]. Four small pieces of piezoelectric sensor put on the top layer of MLI made of polyimide (PI) film and the piezoelectric sensors convert elastic waves induced by dust collision in the PI film to electric signals. Momentum transfer from the collided dust particles to the PI film is proportional to signal strength (Please refer to [1] for technical detail of measurement principle). The signals are fed by cables to an electronics box of CMDM and the signal waveforms are sampled by A/D converter and stored in a memory.

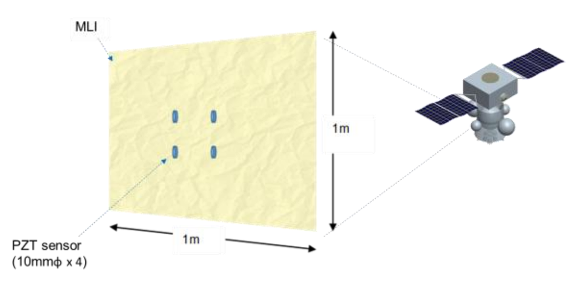

Figure 1: Conceptual drawing of CMDM sensor. (Note that the drawing of the spacecraft is not actual MMX design.)

3. Observation target

The MMX spacecraft will take Hohmann orbit to reach the Mars orbit and will be inserted into the orbit around the Mars. The sensor of the CMDM shall be pointed to the ram direction of the MMX spacecraft to increase the probability of collision with dust particles in orbit. In the following sections, we describe dust particles as observation target while the MMX spacecraft will be in the cruising orbit and the orbit around the Mars.

3.1 Cruising orbit to the Mars

In past space-borne missions, there was a similar attempt of *in-situ* direct measurements of the Martian dust environment which were planned to use the Mars Dust Counter (MDC) aboard *Nozomi*, the Japanese Mars explorer. During cruising orbit to the Mars orbit, the MDC measured nearly 100 dust particles during three years of operation in an eccentric orbit between Earth and Mars [4]. CMDM has a large-sensitive-area of $1 m^2$, and higher threshold in size for detection, approximately 3 μm for typical impact speeds of interplanetary dust (~ $10 kms^{-1}$). For such large-sized background interplanetary dust particles, the detection rate is expected to be ~0.3 m^{-2} day^{-1} by CMDM. Recent work of cometary dust trail simulations shows that CMDM may have chance to detect enhancement in dust flux due to cometary trail passing through while the MMX spacecraft is taking Hohmann orbit for cruising to the Mars [5].

3.2 Quasi-satellite orbit around the Martian Moons

After the MMX is inserted into the orbit around the Mars, the spacecraft will be settled into "quasi-satellite" orbit [3], which is almost circular orbit and will co-rotate with Phobos for first and Deimos afterwards. Krivov and Hamilton [6] predicted the number density of 30 μm or larger dust particles for Phobos' ring to be 6.8×10^{-6} m^{-3}, while the density of 15 μm or larger dust particles for Deimos was predicted to be 9.7×10^{-5} m^{-3}. They also predicted relative speeds of the particles into Phobos are 0.58 km/s to 0.68 km/s and 0.16 to 0.82 km/s for Deimos. The MMX spacecraft will be in almost same orbits as Phobos/Deimos, therefore those dust particles hit onto CMDM sensor in speeds above. CMDM is impact sensor and measure only momentum transfer from a collided dust particle. We can determine ring/torus dust particles by measuring the flux to see enhancement more than the background interplanetary dust particles.

4. Summary

We are developing a CMDM for JAXA MMX mission. The MMX spacecraft is planned to be launched in 2024 to investigate Phobos and Deimos. We exploit the opportunity of the MMX mission to seek undiscovered Martin dust ring/torus and also detect cometary trail dust particles on the way to the Mars.

Acknowledgements

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References

[1] M. Kobayashi, H. Krüger, H. Senshu, K.Wada, O. Okudaira, S. Sasaki, and H. Kimura.: *In situ* observation of dust particles of Martian dust belts by a large-sensitive-area dust sensor., PSS, **156**, 41–46, 2018. doi: 10.1016/j.pss.2017.12.011.

[2] S. Soter. The dust belts of Mars. Technical report, Center for Radiophysics and Space Research Report No. 462, 1971.

[3] Kuramoto, K., Kawakatsu, Y., Fujimoto, M., Genda, H., Imamura, T., Kameda, S., Matsumoto, K., Miyamoto, H., Morota, T., Nagaoka, H., Nakamura, T., Ogawa, K., Otake, H., Ozaki, M., Sasaki, S., Senshu, H., Tachibana, S., Terada, N., Usui, T., Wada, K., Watanabe, S. and MMX Study Team. Martian Moons Exploration (MMX) Conceptual Study Update. EPSC 2018, id.EPSC2018-1036.

[4] Sasaki, S., Igenbergs, E., Ohashi, H., Senger, R., Münzenmayer, R., Naumann, W., Grün, E., Nogami, K., Mann, I., Svedhem, H., 2007. Summary of interplanetary and interstellar dust observation by Mars Dust Counter on board *NOZOMI*. ASR, **39**, 485–488, 2007.

[5] Krüger, H., Kobayashi, M., Sasaki, S., Soja, R., Sommer, M., Strub, P., Srama, R., Moragas-Klostermeyer, G., Kimura, H., Hirai, T., Arai, T., Ishimaru, R., Grün, E.: Cometary dust trail simulations for the Martian Moons Exploration (MMX) mission, EPSC-DPS Joint Meeting 2019 (This conference).

[6] Krivov, A. V., Hamilton, D. P., 1997. Martian Dust Belts: Waiting for Discovery. Icarus **128**, 335–353.