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**Introduction:** Mercury Dust Monitor (MDM) will be on board the Mercury Magnetosphere Orbiter (MMO) of BepiColombo. BepiColombo MMO will be launched in 2015 and will arrive at the orbit around Mercury in 2022 and its nominal operation will be for one year [1]. So far, Helios was the only mission that conducted in-situ observation of dust particles near Mercury's orbit [2] in the inner solar system between heliocentric distance of 0.31 and 1.0 AU. No mission, however, has made in-situ observations of the dust of Mercury. The BepiColombo MDM will perform the first in-situ dust detection in Mercury's orbit.

In this paper, we report an overview of the BepiColombo MDM.

**Instrumentation:** BepiColombo MMO is a spin-stabilized spacecraft as the Helios spacecraft and the MDM will be installed on the side panel to face an in-plane direction of ecliptic similar to the ecliptic sensor of the Helios Micrometeoroid Analyzers. The BepiColombo MDM uses four plate sensors of piezoelectric lead zirconate titanate (PZT) because it has (1) a simple configuration, (2) a large sensitive area compared with the mass of the system (220 g for the sensor part, 381 g for the electronics), (3) a high-temperature tolerance up to +230 °C, and (4) no bias voltage needed. The BepiColombo MMO is smaller than Helios by about 100 kg, thus the resource for its science payloads especially for its occupied volume is very severe; however, the MDM configuration met such a tight requirement for the science instruments. The MDM has a sensitive area of 64 $cm^2$ with open aperture and the nominal observation is for 1 year. Thus, the MDM is predicted to attain a similar count rate of interplanetary dust to the Helios Micrometeoroid Analyzer although it depends on the lower limit of detectable mass range.

**Orbit and Observation:** In contrast to Helios, the BepiColombo MMO will be in an elliptic orbit around Mercury with the perihermion of 400 km and the aphermion of 11824 km. The orbital inclination is 90°, the orbital period is 9.3h. Thus, the Mercury-centric dependence of dust flux will be investigated, near the apoherm the MDM can predominantly detect dust particles from interplanetary space, while near periherm it may detect dust particles launched from the Mercury surface by meteoroid bombardments [3] or by an electrostatic force near the terminator as suggested also in the lunar dust environment [4]. The in-situ observation of dust particles will contribute to a study of the Na atmosphere of Mercury as mentioned in the section below.

**Science Significance of Dust Observation in Mercurial Orbit:** The goal of the MDM is the detection of Mercury ambient dust particles and new insight into the environment of dust particles in the inner solar system.

*Dust sciences related to Mercury.* The incoming dust particles to Mercury are related to the space weathering of the surface materials, the origin of Mercury's atmosphere, and dust particles of Mercurial origin. Micrometeoroid impact might contribute to the formation of the tenuous Na atmosphere [5] and the space weathering effect can constrain the chronology of the Mercurial surface. For those purposes, the observation of temporal and directional variations in the dust influx throughout Mercurial orbit is important and it leads an estimation of the external mass accretion rate to the Mercurial surface.

The outgoing dust particles from Mercury are related to Mercurial dust ejection by meteoroid impacts, similar to the Jovian satellites and also levitating dust. Those dust particles possibly have interaction with the magnetic field, similar to the Jovian dust streams.

*Dust sciences of the inner solar system.* In addition to Keplerian interplanetary dust (IPDs) that slowly spirals to the Sun by the Poynting-Robertson effect, we consider other dust components: dust trails of near-Sun comets, β meteoroids, and interstellar dust (ISD) around Mercury's orbit.

**Distinction of Dust Components by In-situ Observation:** Dust particles around Mercury should be distinguished on the basis of their origins: ISD, IPD, β meteoroids, and possibly dust particles that originated from Mercury. The MDM can measure only the momentum of the incident dust particles and so their origins have to be inferred from their orbit properties: the detected position in the orbit and the arrival directions. Table 1 summarizes rough criteria for distinction of dust particles around Mercury. If the population of dust components around Mercury is determined by in-situ observation, we can increase our knowledge of the contribution of inflow and outflow dust particles to/from Mercury's surface materials.

Table 1. Properties of dust particles detectable in the orbit around Mercury

| Dust | Origin | Kinematic Properties |
|---|---|---|
| Interstellar dust | Interstellar medium | 25 km/s<br>ecliptic longitude of 252º<br>& ecliptic latitude of 5º |
| Interplanetary dust | Cometary and asteroidal materials | < 77 km/s<br>Anti-apex of the Mercury or higher eccentricities and various inclinations |
| $\beta$ meteoroid | Interplanetary dust swept by solar radiation | > 77 km/s<br>Solar direction |
| Ejecta cloud | Materials on the Mercury surface, regolith | > 0 km/s<br>Mercury direction |
| Levitating dust | Materials on the Mercury surface, regolith | > 0 km/s<br>Mercury direction |

**Ground Experiment for Performance Check and Calibration:** To determine the physical parameters of impacting dust particles, such as velocity, mass, and momentum, from the impact signals of the sensors, we need to obtain empirical formulae for calibration through ground experiments. For the calibration, we have implemented a dust acceleration test campaign using a high voltage Van de Graaff dust accelerator at the Max Planck Institute for Nuclear Physics in Heidelberg, Germany, in April 2012. This experiment was performed to qualify the flight sensors and to evaluate the functionality of the MDM system. Four flight PZT sensors were selected out of the whole sensor set that we made including spare sensors and to evaluate the functionality of electronics of the MDM-E in terms of sensitivity. This experiment was significant to determine the lower limit of the dynamic range of dust momenta. In the experiment, dust particles of iron were accelerated with the speeds in the range between 0.5 and 10 km/sec and with the sizes of up to 2 µm. The waveforms of impact signals from the PZT sensors of the MDM are processed with Fast Fourier Transformation to make frequency spectra. The spectra have a strong resonance peak for a real dust impact event and the intensity of the resonance peak around 1.1 MHz has linearity with the momentum transfer of an incident dust particle. For future analysis of observation data, calibration curves will be produced from the relation between the momenta of dust particles measured in the accelerator and the resonance peak intensity for individual sensors.

**Science Synergy of Bepi Colombo Mission:** BepiColombo MMO MSASI (Mercury Sodium Atmosphere Spectral Imager) studies thin sodium atmosphere of Mercury. The generation process of Na atmosphere might be related to dust bombardment to Mercury's surface. BepiColombo MPO SIMBIO-SYS (Spectrometers and Imagers for MPO BepiColombo Integrated Observatory SYStem) [6] is the complex instrument that will provide images and spectra in Vis/NIR range of the entire surface of Mercury. Dust bombardment causes space weathering on Mercury's surface that affects IR spectra.

**Concluding Remarks:** As of writing this paper, we are analyzing our ground experiment data for the calibration of the electronics in order to determine the lower limit of the measurable range of dust particle momentum and the flight model of the MDM is undergoing the final integration test and required environment tests in JAXA/ISAS test facility.

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