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Exploraion of the innermost planet Mercury's environment by BepiColombo

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Abstract

Mercury, the innermost planet in the solar system, has the weak planetary magnetic field and forms its magnetosphere. Mercury's magnetosphere is one of the best targets to study a planetary environment exposed to extreme stellar wind. The first Mercury orbiter MESSENGER explored this region and discovered a wide variety of phenomena. However, due to the highly ecliptic orbit with north-south asymmetry and limited capability for plasma measurements, many science topics still remain unsolved. The Mercury Magnetospheric Orbiter (MMO) for the BepiColombo mission will be launched in October 2018. MMO has a complete package of plasma instruments. Here we present how it can contribute to deepen our understanding Mercury's environment by addressing the puzzles raised by MESSEGNER

Introduction

Mercury has the weak planetary magnetic field stands against the intense solar wind in the close proximity of the Sun. Mercury's plasma environment is quite different in the parameters from the well-studied terrestrial magneto-sphere. In addition, recently many Earth-type exoplanets orbiting in habitable zones very close to cool stars (M-dwarfs) were found. Such exoplanets are exposed to extreme stellar winds and ultraviolet radiations. Thus Mercury's magnetosphere is one of the best targets to study planetary environments. Exploring Mercury which is the innermost planet in the solar system plays a key role to understand such extreme environment.

The first Mercury orbiter MESSENGER explored this region and discovered a wide variety of phenomena. For example, Mercury's magnetosphere is much more dynamic than one had predicted. However, due to the highly ecliptic orbit with north-south asymmetry and limited capability for plasma measurements, many science topics still remain unsolved.

The next Mercury exploration mission BepiColombo, which is the international joint project between ESA and JAXA, will be launched in October 2018 and will arrive at Mercury in December 2025. The JAXA's spacecraft Mercury Magnetospheric Orbiter (MMO) is equipped to study the space environment of Mercury. MMO is mainly designed for plasma observations with the complete package of plasma instruments consortium and is expected to extract essential elements of space plasma physics that become visible in the Hermean environment. In addition, ESA's Mercury Planetary Orbiter (MPO) also has several instruments for plasma measurements, so we can investigate Mercury's environment with two points measurements.

BepiColombo/MMO

The MMO spacecraft will have a ecliptic polar orbit with a period of 9.3 hours, a periapsis of 590 km, and a apoapsis of 11640 km. The orbital plane is same as that of MPO. The MMO will be spin-stabilized with a rotation rate of 15 rpm and a spin axis almost perpendicular to the orbital plane of Mercury around the Sun.

MMO has a complete package of plasma environment measurements: Magnetic Field measurement (MGF), Plasma Wave Instrument (PWI), and Mercury Plasma Particle Experiment (MPPE). These instrument will be operated as a plasma measurement consortium. In addition, two more instruments are installed onboard MMO to investigate Mercury's exosphere and dust environment: Mercury Sodium Atmospheric Spectral Imager (MSASI) and Mercury Dust Monitor (MDM). The instruments onboard MMO are listed in Table 1. It also includes

the comparison with the similar instruments onboard MESSENGER.

Table 1: Science instruments list onboard MMO

	BepiColombo/MMO				MESSENGER	
Plasma (SW, MS)	MPPE	MEA	Low-energy electrons	3eV-26keV	-	
		MIA	Low-energy ions	15eV-29keV	FIPS	50eV-13keV 1-40 amu/e
		MSA	Ion mass spectroscopy	1eV-38keV 1-60 amu/e m/ Δm = 40 (<13keV) m/ Δm = 10 (>13keV)		
		HEP-ion	High-energy ions	30keV-1.5MeV	EPS	25keV-1MeV
		HEP-ele	Hihg-energy electrons	30keV-700keV	EPS	25keV-1MeV
		ENA	Plasma imaging	10eV-3.3keV	-	
	MGF		Magnetic field	DC - 64Hz L: <0.25Hz, M: 8Hz	MAG	DC - 20Hz
	PWI		Electric field, plasma wave, radio wave	DC - 10MHz (E) few - 640kHz (B)	-	
Exosphere	MSASI		Na-exosphere image	Spatial resol.: 3-30km R = 65000	MASCS	Spatial reol.: 25-800km R = 1000
Dust	MDM		Dust environment	10s pg*km/s	-	

Almost all of tests in ESA's test center (ESTEC) have successfully finished and soon the spacecraft will be shipped to the launch site in French Guiana. So now we can focus on science observation planning.

MMO has large constraints on science operations, such as thermal issue and limited telemetry rate. Due to the thermal issue each science instrument cannot always be turned on. In addition, due to the low telemetry rate in average, only a part (~20-30%) of science mission data with high resolution can be downlinked. Therefore, in order to maximize the scientific results and outcomes to be achieved by MMO, we are now working to optimize the science observation and downlink plans in detail.