EPSC Abstracts
Vol. 13, EPSC-DPS2019-216-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

BepiColombo – The next step of Mercury Exploration with two orbiting spacecraft

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Abstract

The BepiColombo spacecraft was launched on 20 October 2018 from the European spaceport in French Guyana. A mission overview is provided with the summary of the results from the near-Earth commissioning phase. An outlook of the upcoming spacecraft and payload activities is given.

1. Introduction

Mercury is in many ways a very different planet from what we were expecting. On 20 October 2018 the BepiColombo spacecraft [1] started its 7 year journey to the innermost terrestrial planet to investigate on the fundamental questions about its evolution, composition, interior, magnetosphere, and exosphere.

BepiColombo is a joint project between the European Space Agency (ESA) and the Japanese Aerospace Exploration Agency (JAXA). The Mission con- sists of two orbiters, the Mercury Planetary Orbiter (MPO) and the Mercury Magnetospheric Orbiter (MMO). From their dedicated orbits the two space- craft will be studying the planet and its environment.

The mission has been named in honor of Giuseppe (Bepi) Colombo (1920–1984), who was a brilliant Italian mathematician, who made many significant contributions to planetary research and celestial mechanics.

2. Science goals

BepiColombo will study and understand the composition, geophysics, atmosphere, magnetosphere and history of Mercury, the least explored planet in the inner Solar System. In particular, the mission objectives are:

• to understand why Mercury's uncompressed density is markedly higher than that of all other terrestrial planets, Moon included

• to understand and determine the nature of the core of Mercury

• to understand why such a small planet pro- cesses an intrinsic magnetic field and investigate Mercury's magnetized environment

• to investigate if the permanently shadowed craters of the Polar Regions contain Sulphur or water ice

• to study the production mechanisms of the exosphere and to understand the interaction between planetary magnetic field and the solar wind in the absence of an ionosphere

• to obtain new clues about the composition of the primordial solar nebula and about the formation of the solar system

• to test general relativity with improved accu- racy, taking advantage of the proximity of the Sun. Since and considering that the advance Mercury's perihelion was explained in terms of relativistic space-time curvature.

3. Science Payload

The MPO scientific payload comprises eleven instruments/instrument packages and the MMO comprises 5 instruments/instrument packages to study the planet itself and its environment, respectively. The MPO will focus on a global characterization of Mercury through the investigation of its interior, surface, exosphere and magnetosphere. In addition, it will be testing Einstein's theory of general relativity. The MMO will focus on the plasma and particle environment and the magnetosphere.

4. Payload Commissioning

The payload commissioning is implemented in several stages. In the first 3 months, a first part of the Near-Earth Commissioning was executed, including the activation of all payload on the MPO and MMO. Several of the instruments have been fully commissioning and can be operated in their scientific observation mode: the magnetometer (MPO-MAG), the accelerometer (ISA), the environmental sensor (BERM), the gamma-ray and neutron spectrometer (MGNS), the infrared spectrometer (MERTIS), the solar intensity x-ray and particle spectrometer (SIXS), and the imaging x-ray spectrometer (MIXS). Also the radio science experiment (MORE), using the X-band and the Ka-band, were commissioning and are ready to be used. In a second phase of the Near-Earth Commissioning, all instruments using high-voltage will be commissioned, and it is expected to have the following instrument in a scientific operational mode: the ion precipitation analyser (SERENA/MIPA), the ion camera (SERENA/PICAM), and the UV imaging spectrometer (PHEBUS). All other instruments are operational, but can only be used in their scientific modes after the Mercury in-orbit commissioning in early 2026.

5. Opportunities during the cruise phase

The BepiColombo spacecraft is on its way to Mercury in a so-called 'stack' configuration: The MMO and the MPO are connected to each other, and stacked on-top of the Mercury Transfer Module (MTM). Only in late 2025, the 'stack' configuration is abandoned and the individual elements spacecraft are brought in to their final Mercury orbit: 480x1500km for MPO, and 590x11640km for MMO.

Until then, BepiColombo has several opportunities for scientific observations. During the cruise, there are one Earth flyby, two Venus flybys, and six Mercury flybys, during which the instruments that are able to execute scientific observations will be operated on a best effort basis.

Further, there are environmental, favourable opportunities, e.g. the planetary alignment of Mercury, Venus, Earth, Mars, Jupiter, Saturn, and Pluto in July 2020. Also interdisciplinary and inter-spacecraft observations are foreseen with e.g. the Parker Solar Probe [3] and Solar Orbiter [4] (once launched).

6. Expected results

Once inserted into its orbits, the scientific payload of both spacecraft will provide the detailed information necessary to understand Mercury and its Magnetospheric environment and to find clues to the origin and evolution of a planet close to its parent star. The BepiColombo mission will complement and follow up the work of NASA's MESSENGER [2] mission by providing a highly accurate and comprehensive set of observations of Mercury. In addition, the BepiColombo mission will provide a rare opportunity to collect multi-point measurements in a planetary environment. This will be particularly important at Mercury because of short temporal and spatial scales in the Mercury's environment. The foreseen orbits of the MPO and MMO will allow close encounters of the two spacecraft throughout the mission.

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