BepiColombo – ESA/JAXA mission to explore Mercury

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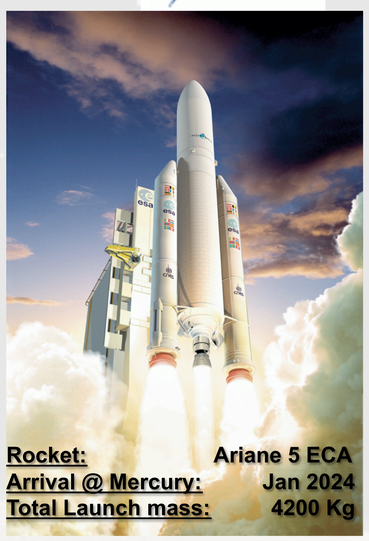


BepiColombo is named after the Italian mathematician Giuseppe (Bepi) Colombo, renowned for his study of interplanetary orbits. He suggested to NASA putting NASA's Mariner 10 spacecraft into an orbit that enabled multiple flybys of the planet

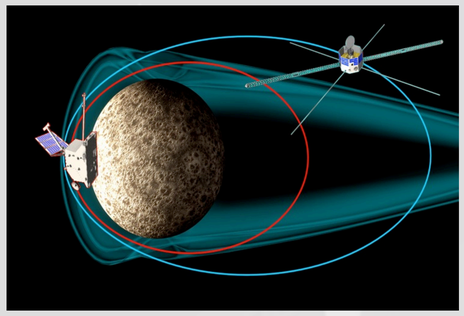
BepiColombo is built in close cooperation with the **Japanese Space Agency JAXA**. It is ESA's first experience of sending a planetary probe to very 'hot' regions. Most of the agency's previous interplanetary missions have been sent to relatively cold parts of the Solar System.

BepiColombo is an especially challenging mission because Mercury's orbit is very close to the Sun. This makes the planet difficult to observe from a distance, because the Sun is so bright, but this also makes it difficult to investigate from an orbit around the planet.
Spacecraft and instruments must be shielded against the infrared heat from the planet, the radiation environment close to the Sun, and a ten times higher solar insolation than on Earth.

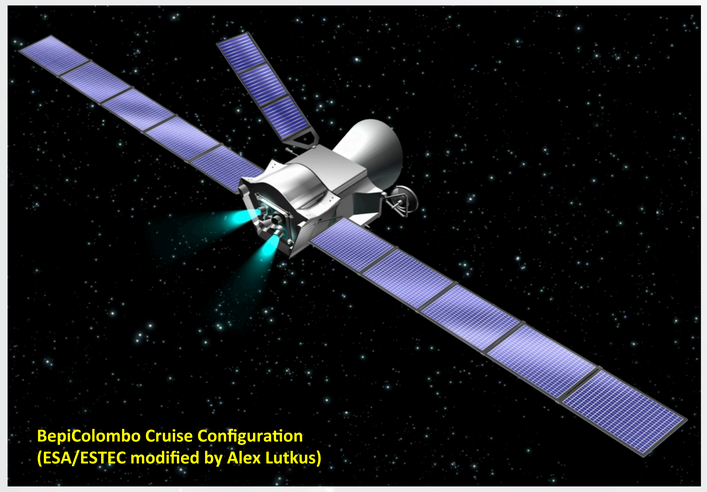
Two spacecraft .....

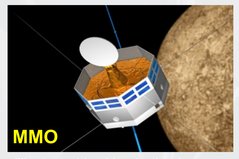
◆**Mercury Magnetospheric Orbiter (MMO)**
- ❖focus on the planetary environment
- ❖built under JAXA responsibility
- ❖Initial orbit: polar 590x11,640 km, 9.2 hr period

◆**Mercury Planetary Orbiter (MPO)**
- ❖focus on the surface and interior science
- ❖built under ESA responsibility
- ❖Initial orbit: polar 480x1,500 km, 2.3 hr period

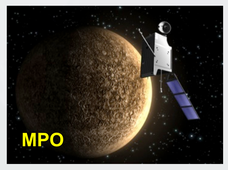


The MPO is provided by ESA with 11 science instruments on board funded via national agencies and is dedicated to investigate the planet itself comprehensively**. The MMO is provided by JAXA** and contains five instruments/instrument suites. It will thoroughly investigate Mercury's environment, including its magnetosphere.

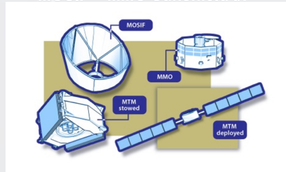




(illustrated by Alex Lutkus)



MTM – Mercury Transfer Module
MOSIF – MMO Sunshield I/F



Science Topics and Science Goals of BepiColombo

Mercury as a planet:

- ❖ surface morphology and topography (< 10m accuracy)
- ❖ surface age (observation of craters > 500m diameter)
- ❖ mineralogical and Elemental Composition (thermal IR spectral range 7-14µm, spectral resolution 200nm; near IR 0.4 - 2µm)
- ❖ determination of abundance of key elements (X-ray telescope better than 200km spatial resolution; MGNS)
- ❖ search and identify signatures of unexpected species
- ❖ study mass, figure and moment of inertia (moment of inertia factor C/MR2 with accuracy better 0.003; second degree tidal Love number k with Signal/Noise ~ 50)
- ❖ chemistry of the surface
- ❖ surface heat flow

Origin of Mercury's magnetic field:

- ❖ map magnetic field
- ❖ separation of internal/external sources

Exosphere:

- ❖ composition and vertical structure
- ❖ search for noble gases, isotopes, molecules, atoms from crustal origin, composition and dynamics (UV range 50-300nm)
- ❖ surface release processes
- ❖ search for Ionosphere, Exosphere/Magnetosphere exchange and transport processes

Magnetosphere:

- ❖ structure, dynamics, interaction with planet

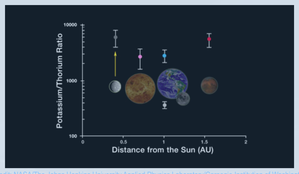
Relativity and Gravitational Physics:

- ❖ test general relativity and alternative theories of gravity
- ❖ determine the gravitational oblateness of the Sun (J2) (accuracy up to $2*10^{-9}$)
- ❖ set improved upper limits to the time variation of the gravitational constant (d(ln*G*)/*dt*) (accuracy up *to* $3*10^{-13}$ *years*$^{-1}$)

Mercury is not very different from the Moon

From NASA's MESSENGER we know everything about Mercury

Lessons Learned from MESSENGER



Credit: NASA/The Johns Hopkins University Applied Physics Laboratory/Carnegie Institution of Washington

High Potassium/Thorium ratio indicates that Mercury contains much more volatile material than expected from formation models
➔ Formation models to be re-written?

Water ice in deep craters at the pole consistent with all kinds of measurements
➔ What is the origin of the polar ice ?

Large expanses of volcanic deposits on Mercury
➔ What is the source of volcanism / What triggered the lava flow ?

High-albedo, white-blue floor deposits (Hollows) suggest a more abundant volatile component in Mercury's crust
➔ What cause the formation of hollows ?

Contraction on Mercury has caused deep faults and cracks
➔ What is the thermal history of the planet?

Gravity anomalies @ northern hemisphere
➔ Does one find similar anomalies in the south?

BepiColombo instruments (MMO)

MGF (2 sub-units)	**Magnetic Field Investigation studies** magnetic field from the planet, magnetosphere, and interplanetary solar wind. PI: W. Baumjohann, Austrian Academy of Science, Austria.
MPPE (7 sub-units)	Mercury **Plasma Particle Experiment studies** plasma & neutral particles from the planet, magnetosphere, and interplanetary solar wind. PI: Y. Saito, ISAS, JAXA, Japan.
PWI (7 sub-units)	**Plasma Wave Investigation studies** electric field, electromagnetic waves, and radio waves from magnetosphere and solar wind. PI: Y. Kasaba, Tohoku University, Sendai, Japan
MSASI	Mercury Sodium Atmosphere Spectral Imager **studies the thin sodium atmosphere.** PI: I. Yoshikawa, Univ. Tokyo, Japan.
MDM	Mercury **Dust Monitor** studies dust from the planet and interplanetary & interstellar space. PI: H. Shibata, Kyoto Univ., Japan.

BepiColombo will provide:

- comprehensive, high resolution global coverage
- infrared images, surface composition, global temperature maps
- global 3-dimensional (stereo) coverage of the surface
- accurate measurements of Mercury's gravity field (planet interior, test of Einstein's theory)
- high-detail measurements of the plasma and particle environment
- BepiColombo will follow up on MESSENGER results
- BepiColombo will to close the gaps in the southern hemisphere

BepiColombo instruments (MPO)

MIXS	**Mercury Imaging X-ray Spectrometer** *Elemental surface composition, global mapping and composition of surface features* PI: Emma Bunce (United Kingdom)
MPO/MAG	**Magnetic Field Investigation** *Detailed description of planetary magnetic field, its source and interaction with the solar wind* PI: Karl-Heinz Glassmeier (Germany)
MGNS	**Mercury Gamma-Ray and Neutron Spectrometer** *Elemental surface and sub-surface composition, volatile deposits on polar areas* PI: Igor Mitrofanov (Russia)
MORE	***Mercury Orbiter Radio Science Experiment*** *Core and mantle structure, Mercury orbit, fundamental science, gravity field* PI: Luciano Iess (Italy)
SERENA: Elena, MIPA, PICAM, Strofio	**Search for Exospheric Refilling and Emitted Natural Abundances** *In-situ study of composition, vertical structure and source and sink processes of the exosphere* PI: Stefano Orsini (Italy)
PHEBUS	**Probing of Hermean Exosphere by Ultraviolet Spectroscopy** *UV spectral mapping of the exosphere* PI: Eric Quemerais (France)
MERTIS	**Mercury Radiometer and Thermal Imaging Spectrometer** *Global mineralogical mapping (7-14 µm), surface temperatures and thermal inertia* PI: Harald Hiesinger (Germany)
SIXS	**Intensity X-ray and particle spectrometer** *Monitor solar X-ray intensity and solar particles* PI: Juhani Huovelin (Finland)
SIMBIO-SYS: HIRC, STC, VIHI	**Spectrometers and Imagers for MPO** *High resolution and stereo imaging, Near-IR (<2.0µm) imaging spectroscopy for global mineralogical mapping* PI: Enrico Flamini (Italy)
BELA	**BepiColombo Laser Altimeter** *Topographic mapping* PIs: Tilman Spohn (Germany), Nicolas Thomas (Switzerland)
ISA	**Italian Spring Accelerometer** *Non–gravitational accelerations of the spacecraft* PI: Valerio Iafolla (Italy)

BepiColombo will be launched in July 2016
Backup Launch opportunities in Jan/Mar/July 2017
Please not that the arrival at Mercury for all options will be January 2024 and the start of science phase in April 2024