BepiColombo fly-by's at Venus

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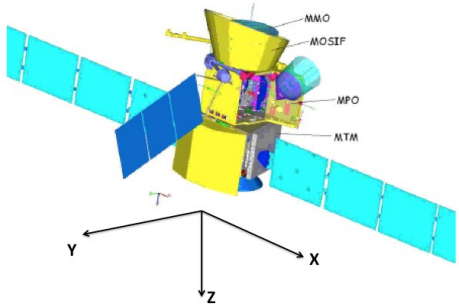
Cruise & flybys at Venus



Both spacecraft will be launched in a composite with a propulsion element, the Mercury transfer module **(MTM)** and a sunshade cone to protect the MMO **(MOSIF).**
During the long cruise to Mercury (about 6.5 years), BepiColombo will have **two fly-by's at Venus in 2019 and 2020**.
Due to the composite launch and cruise configuration (MCS) of both spacecraft, together with the propulsion element, during cruise not all the instruments will be able to operate.
MMO will be mainly shielded by MOSIF, thus allowing instruments to detect signals only within a conical field-of-view around the MCS's –Z axis**. MPPE/ENA** is an ENA detector that could be operated.
On the **MPO** only the instruments non-obstructed by the MTM or not requiring pointing. This implies: **ISA** (accelerometer), **MPO-MAG** (magnetometer), **MERTIS** (magnetometer-radiometer), MGNS (neutron and gamma ray spectrometers), **MORE** (radio-science), **PHEBUS** (spetrometer), **SERENA/MIPA** and **SERENA/PICAM** (ion detectors), **SIXS** (X-ray and particle spectrometer).

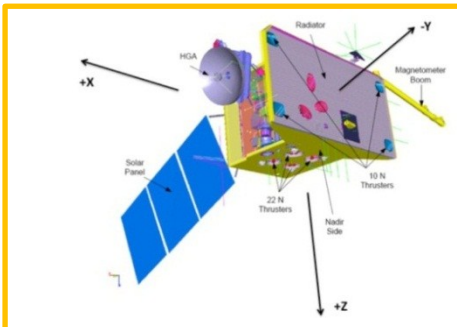
Abstract: BepiColombo mission to Mercury

BepiColombo is a dual spacecraft mission to Mercury **to be launched in April 2018** and carried out jointly between the European Space Agency **(ESA)** and the Japanese Aerospace Exploration Agency **(JAXA).**

The first spacecraft, the Mercury Planetary Orbiter **(MPO)** comprises **eleven experiments** and will focus on a global characterization of Mercury through the investigation of its interior, surface, exosphere and magnetosphere. In addition, it will test Einstein's theory of general relativity. The second spacecraft, the Mercury Magnetosphere Orbiter **(MMO),** led by JAXA, will carry **five experiments** to study the environment around the planet including the planet's exosphere and magnetosphere, and their interaction processes with the solar wind.

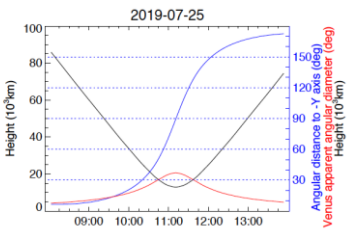
An extensive suite of high resolution scientific instruments, flying on the two spacecraft, allows addressing a wide range of scientific questions that will provide important clues on the origin and formation of Mercury as well as the terrestrial planets in general.

	Venus 1	Venus 2
Flyby Date	2019- 7-25	2020- 5-20
MJD2000	7145.5	7445.4
Solar Longitude	108.8°	-129.5°
Flyby velocity	7.30 km/s	7.54 km/s
Flyby altitude	12891 km	1000 km
Deflection angle	28.2°	53.2°
Pericentre		
Declination	-26.4°	13.7°
Right ascension	90.9°	133.0°
Incoming velocity		
R-component	7.01 km/s	-7.26 km/s
S-component	1.32 km/s	-2.02 km/s
T-component	-1.55 km/s	-0.02 km/s
Declination	-12.3°	-0.2°
Right ascension	10.7°	-164.5°
Outgoing velocity		
R-component	7.06 km/s	-2.78 km/s
S-component	-1.86 km/s	-6.81 km/s
T-component	0.03 km/s	-1.62 km/s
Declination	0.2°	-12.4°
Right ascension	-14.8°	-112.2°

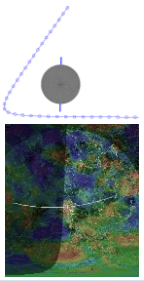


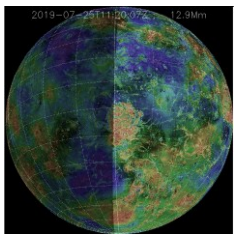
BepiColombo/MPO: configuration and axes

1st Venus Flyby (2019-7-25)



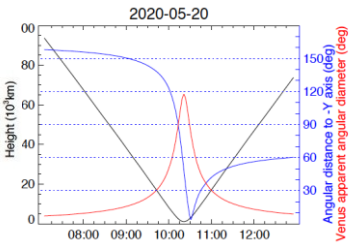
View from the Sun



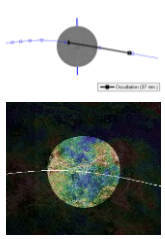


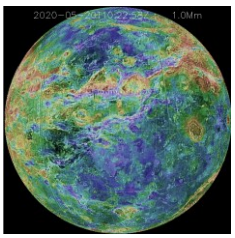
Venus surface seen at minimum distance (almost 13000 Km)

2nd Venus Flyby (2020-5-20)



View from the Sun

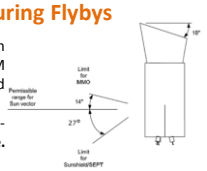




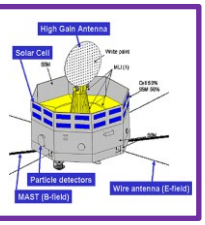
Venus surface seen at minimum distance (1000 Km)

Attitude Constraints during Flybys

Sun illumination is avoided on MMO, on the MPO and MTM radiators, on the SEP thrusters and on the CPS cones.
Sun shall always be kept in the Y/Z-plane within an **allowed SAA range.**



BepiColombo/ MMO



MPO Instruments	Operativity Range	Science at Mercury	Science at Venus
ISA accelerometer	$3\cdot10^{-5}$ – $1\cdot10^{-3}$ Hz	Measurements of non-gravitational perturbations	Gravity gradients induced by Venus gravitational field
MPO-MAG magnetometer	±2000 nT ±2 pT	Mapping of the internal magnetic field	Measurements of flux ropes
MERTIS spectrometer (TIS) radiometer (TIR)	7 - 14 μm 7 - 40 μm	Detection of surface compostion, identification of rock-forming materials and mapping surface mineralogy	Highly accurate temperature readings + sounding of clouds at 55-100 km altitude (CO_2, SO_2, H_2SO_4 bands)
MGNS spectrometers: STN SETN MD SHEN GRS	10^{-3}eV -1 keV 0.4 eV - 1 keV 0.4 eV – 500 keV 300 keV – 10 MeV 100 keV – 10 MeV	detection of surface lines and fluxes of Na, Fe, Ti, Al, Mg, Si, Ca, O + radioisotopes K, U, Th + detection of volatile deposits and H	detection of surface lines and fluxes of Na, Fe, Ti, Al, Mg, Si, Ca, O + radioisotopes K, U, Th + detection of volatile deposits and H
MORE radio-science/trasponder	X-band downlink Ka-band downlink	Jointly with ISA: constrain internal structure (core size and physical state) + constrain crust structure and crust-mantle interface	Improvement of planetary ephemerides
PHEBUS spectrometers: EUV FUV	55-155 nm 145-315 nm	Exosphere composition, variability and interaction with surface and plasma environment	H, He and O hot populations + O, O^+, N, C , C^+, CO, H, He, CO, CO^{2+}, NO (nightside) + CO_2 and O_3 density and temperature
SERENA/MIPA ion detector	10 eV/q to 15 keV/q 1, 2, 4, 8, 16, and 32 amu/q	Plasma precipitation rate, planetary response to SW variations, magnestosphere structure and dynamics	Measurements of solar wind, boundary crossing, pick-up ions from bow shock, ion escape flux and ionosphere composition
SERENA/PICAM ion detector	thermal up to ~ 3 keV up to 132 amu	Characterization of the exo/ionosphere: composition, directions and energies	Solar wind pick-up ions, ion population in the terminator/wake region and in plasma boundaries
SIXS spectrometer	1-20 keV	Monitor solar X-rays, energetic protons and electrons	Monitor solar X-rays, energetic protons and electrons + SEP effects detection
MMO Instruments *(preliminary!)*	**Operativity Range**	**Science at Mercury**	**Science at Venus**
MPPE/HEP-ele	30-700 keV	Election populations at selected ranges	Election populations at selected ranges
MPPE/ENA	10 eV – 3.3 keV	Energetic neutral atoms of the exosphere: detection of H, He, O, Na/Mg-group, K/Ca-group, Fe	Energetic neutral atoms of the Venus environment: detection of H, He, O, Na/Mg-group, K/Ca-group, Fe