

MERCURY's exosphere

From Messenger to Bepi-Colombo

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LATMOS



Outlines



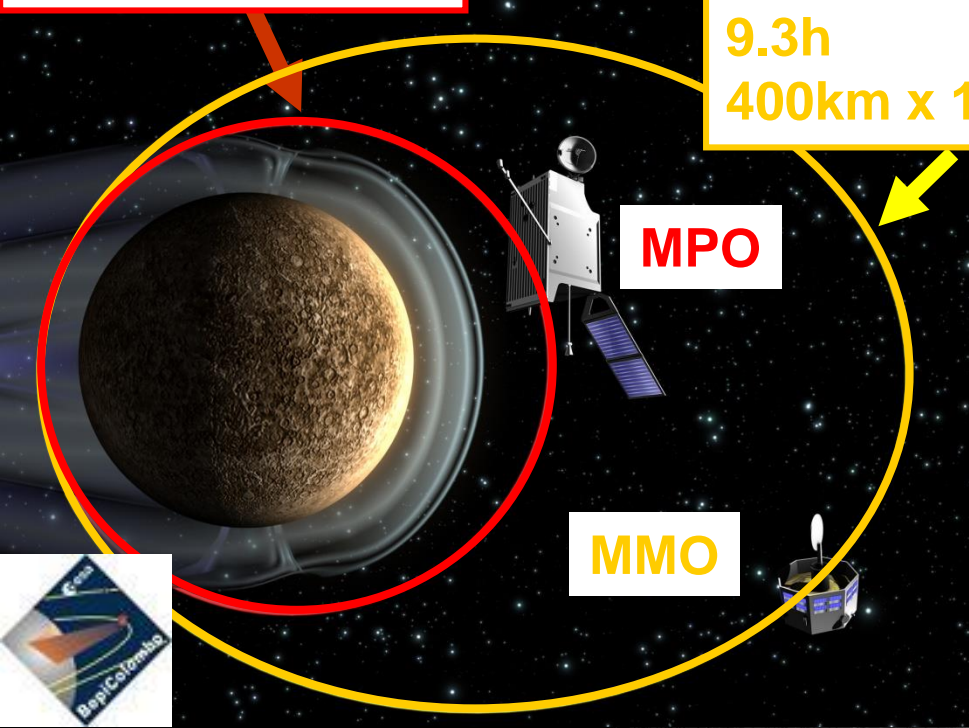
**From Messenger to Bepi-Colombo:
Mission profiles and instruments
(related to exospheric observations)**

**From Messenger to Bepi-Colombo:
What could be Bepi-Colombo exospheric
scientific objectives?**

Mission profile

2.3h
400km x 1500km

9.3h
400km x 12,000km

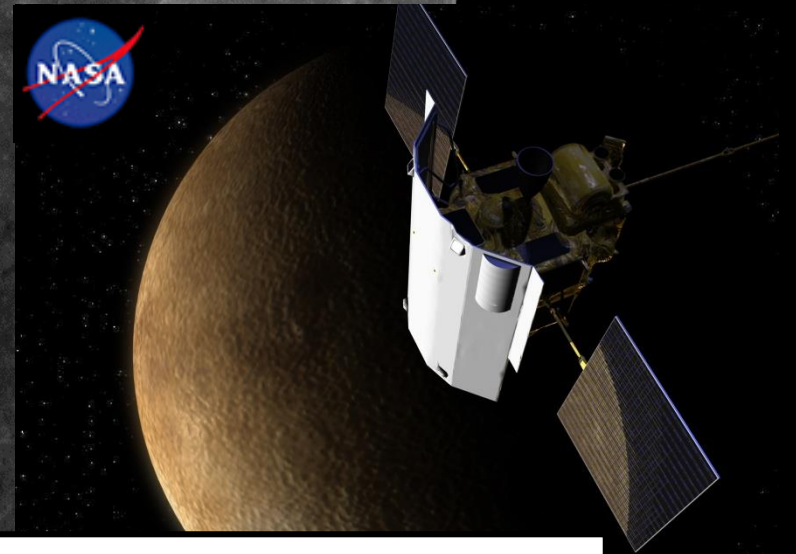


MPO

MMO

Bepi Colombo
An ESA/JAXA Mission

Messenger
A NASA mission



12h
200- 500km x 15,000km

Mission profile

2.3h
400km x 1500km

9.3h
400km x 12,000km

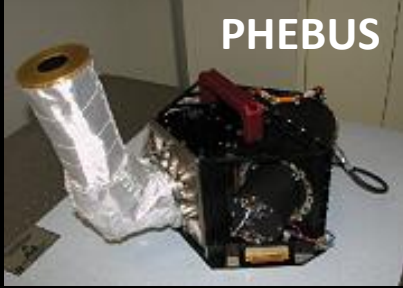
MPO

MMO



Bepi-Colombo exospheric science

- Will benefit of a much larger temporal coverage with MPO and MMO than with MESSENGER,
- Will be able to track time variability of the order of 2 hours,
- Will have two points of view simultaneously.



PHEBUS

**UV Spectrometer
(MPO)**

Neutral exospheric Instruments

STROFIO



**Mass Spectrometer
(MPO)**

**UV and Visible
spectrometer
(MESSENGER)**



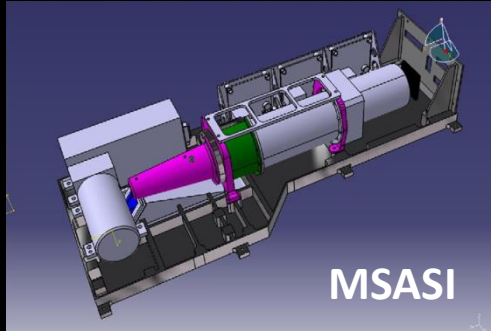
ELENA

**Low Energy neutral
Spectrometer (MPO)**

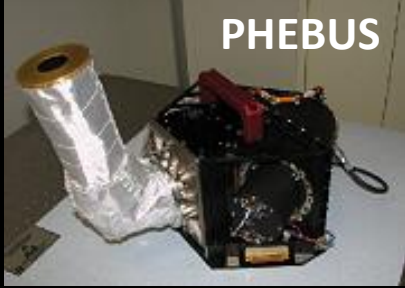


MASCS

**Sodium Imager
(MMO)**



MSASI



PHEBUS

UV Spectrometer (MPO)

Neutral exospheric Instruments

Bepi-Colombo exospheric science thanks to:

- simultaneous in situ and remote sensing measurements,
- two simultaneous points of view (MSASI from MMO vs MPO).

STROFIO

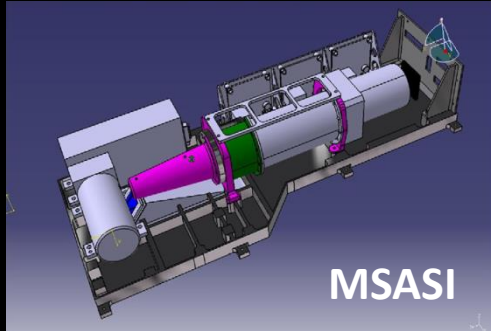


Mass Spectrometer (MPO)



ELENA

Low Energy neutral Spectrometer (MPO)

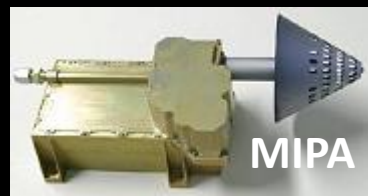


MSASI

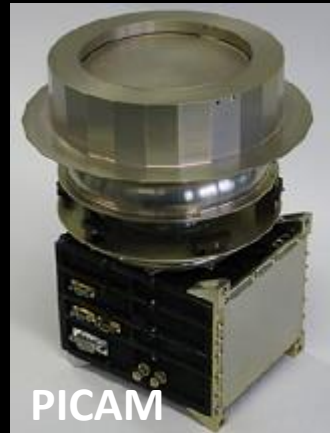
Sodium Imager (MMO)

55 nm	PHEBUS	315 nm + 404 + 422 nm
115 nm	MASCS	610 nm
	589 nm MSASI	589 nm
20 eV	ELENA	5 keV
>10 cm ²	STROFIO	<1eV

Ion « exospheric » Instruments



**Ion mass spectrometer
dedicated to ion
precipitation
(MPO)**



**Ion mass
spectrometer
dedicated to
planetary ion
(MPO)**

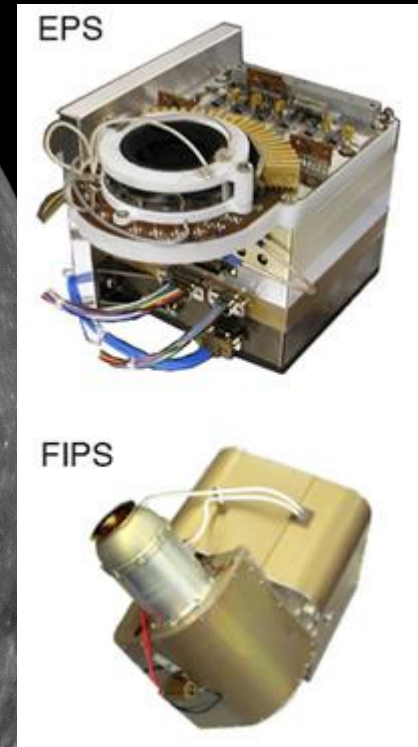


**Ion Mass
spectrometer
(MMO)**



**Magnetometer
(MPO and MMO)**

**Magnetometer
(MESSENGER)**



**Ion mass
spectrometers
(MESSENGER)**



MAG

Ion « exospheric » Instruments

Ion mass spectrometer
dedicated to ion
precipitation (MPO)

Ion mass
spectrometer
dedicated to
planetary ion
(MPO)

Ion Mass
spectrometer
(MMO)

Magnetometer
(MPO and MMO)

Bepi-Colombo exospheric science
thanks to:

- a better temporal, angular and energy coverages of the planetary and precipitating ions,
- a better mass resolution for the planetary ions,
- cross calibration campaigns.

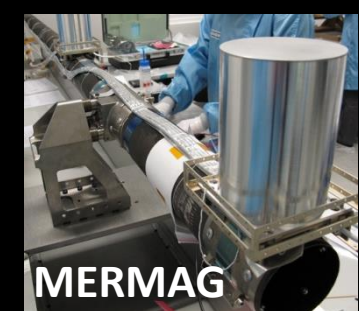
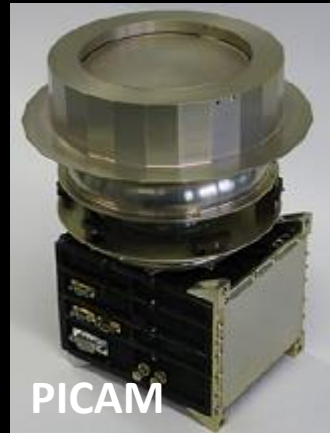
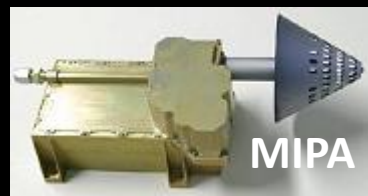
5 eV MIA 30 keV

5 eV MSA 40 keV

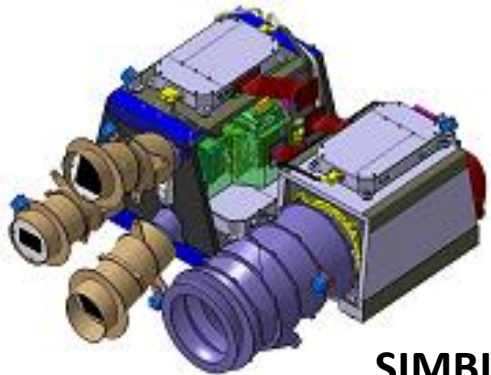
15 eV MIPA 15 keV

5 eV PICAM 3 keV

50 eV FIPS 20 keV



« Boundary » Instruments: Surface



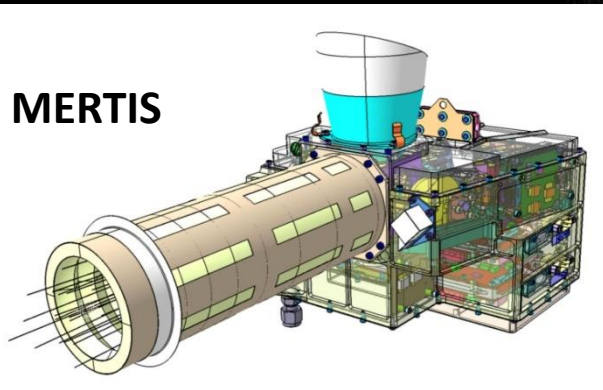
SIMBIO-SYS

Surface geology
and geophysics
mapping
(MPO)

Visible and
near IR
cameras
(MESSENGER)



MDIS



MERTIS

Surface
temperature
and mineralogy
(MPO)

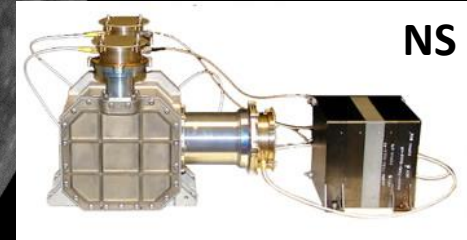


GRS



MIXS

Surface
composition
(MESSENGER)

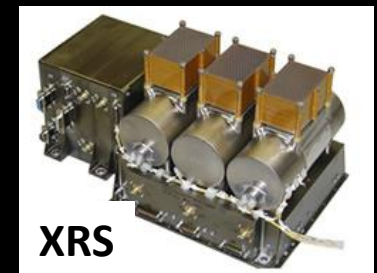


NS

Surface
composition
(MPO)



MGNS

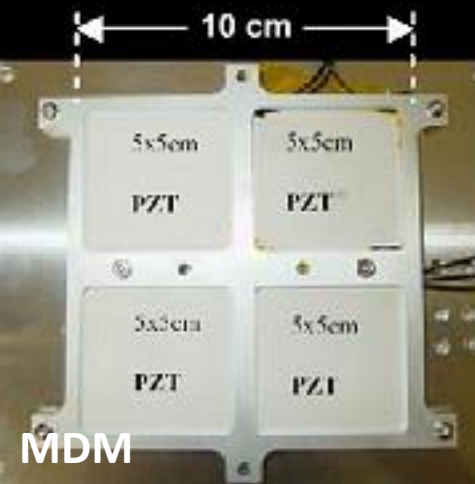


XRS

« Boundary » Instruments: Sun and dust



**Solar X-Ray
and energetic
particles
(MPO)**



**Dust
detector
(MMO)**

Bepi-Colombo exospheric science thanks to

- a better temporal and angular resolution of the surface,
- a measurement of the surface temperature,
- a knowledge of the solar environment,
- a characterization of the dust composition.






**From Messenger to Bepi-Colombo:
What could be Bepi-Colombo exospheric
scientific objectives?**

Science objectives related to Mercury's exosphere

- **Characterization of the temporal evolution (structure and composition along Mercury's year)**
- **Relations with Mercury's environment (composition and structure): solar inputs, surface and dust**
- **Relations with the magnetosphere (composition and structure)**

Characterization of the temporal evolution

Composition of Mercury's exosphere

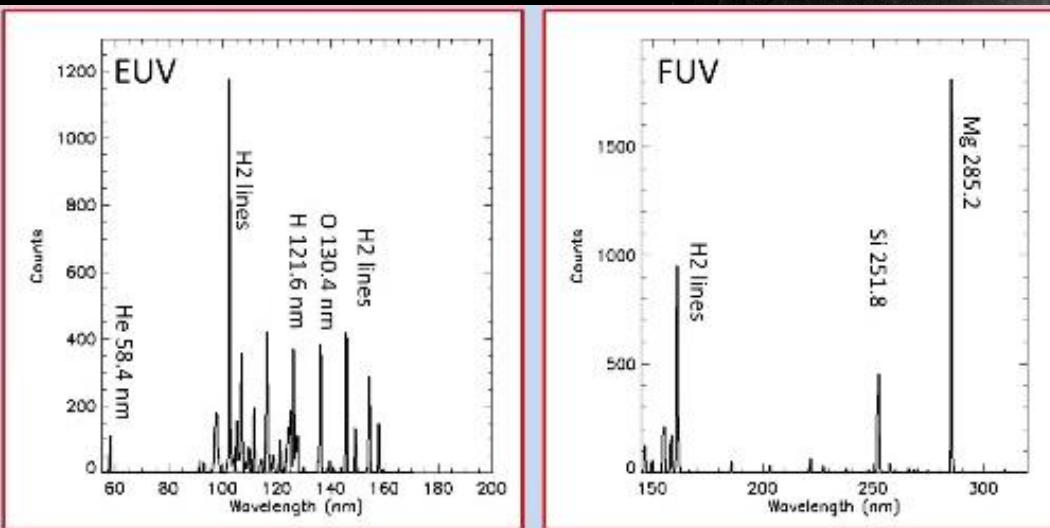
Species	Surface density max (cm ⁻³)	Discovered from:
Na	~ 10 ⁴	
K	~ 10 ²	
Ca	~ 10 ⁴	
H	~ 23 (chaud) 230 (froid)	
He	~ 6×10 ³	
Ca ⁺	?	
Mg	?	

Many others species are expected (see McClintock et al. presentation)

Characterization of the temporal evolution

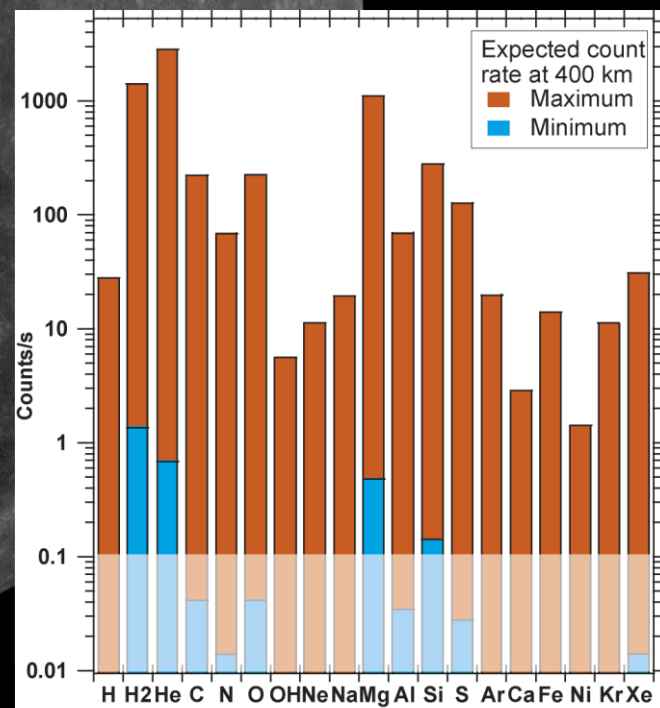
Composition of Mercury's exosphere

PHEBUS/MPO should observe He, H, O, S, Mg, Ca and K



Chaufray et al. (DPS, 2013)

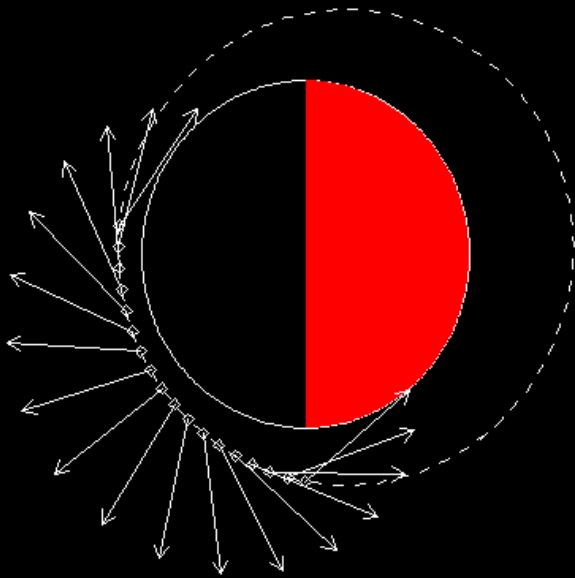
STROFIO/MPO should observe He, Mg, Si...



From BC-SRN-PR-00028

Characterization of the temporal evolution

Structure of Mercury's exosphere (Spatial and temporal)



PHEBUS/MPO
scanning capability
(in the orbit plane):

- ⇒ Coverage
- ⇒ Exposure

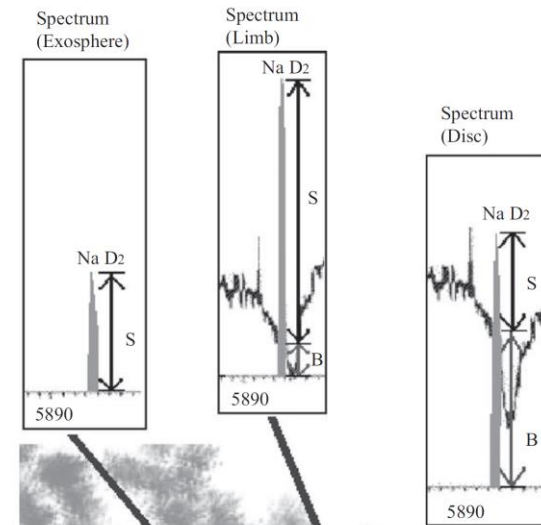
STROFIO/MPO

10 s resolution

In situ variation of
the density along
the S/C trajectory

⇒ Short time
variations

Yoshikawa et al. (2010)



**MSASI/MMO: one image of every
84s to 30 min ⇒ Temporal and
spatial structures of Na exosphere**



Relations with Mercury's environment

Solar inputs

Role of solar events (MMO vs MPO): Electron impact ionization (PICAM), surface sputtering (ELENA and MIPA)

⇒ Can we identify an exospheric signature?

Variation of the exosphere with respect to EUV/UV and X (STIX and PHEBUS/SERENA): Photo-desorption (MSASI, PHEBUS, STROFIO), ionization (PICAM, MSA, MIPA), solar pressure (PHEBUS), MSASI)

Meteoroid bombardement: relations composition, time variation of meteorites (MDM) and exosphere (PHEBUS, SERENA)

Relations with Mercury's environment

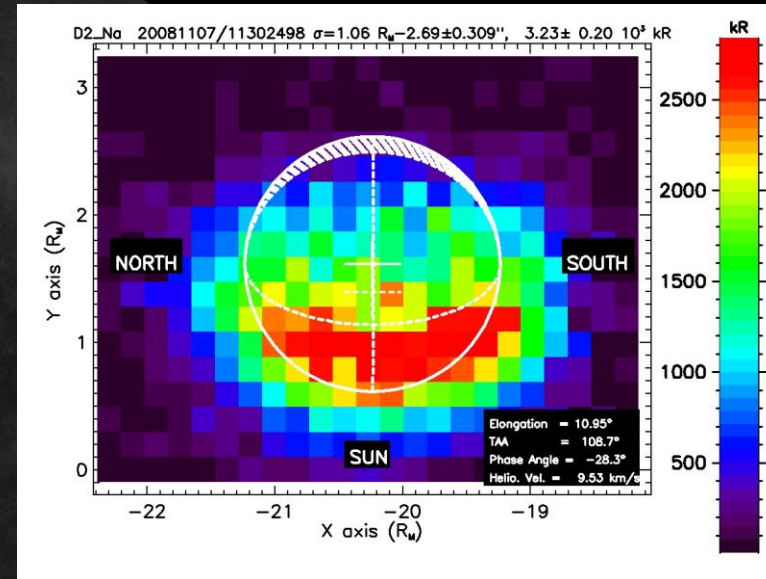
Surface/exosphere relations

Origin of the dawn/dusk asymmetry: temperature relations (MERTIS, PHEBUS, SERENA)?

Exospheric signatures of craters?

None according to MASCS: but species dependent? (SERENA, PHEBUS, SIMBIO-SYS...)

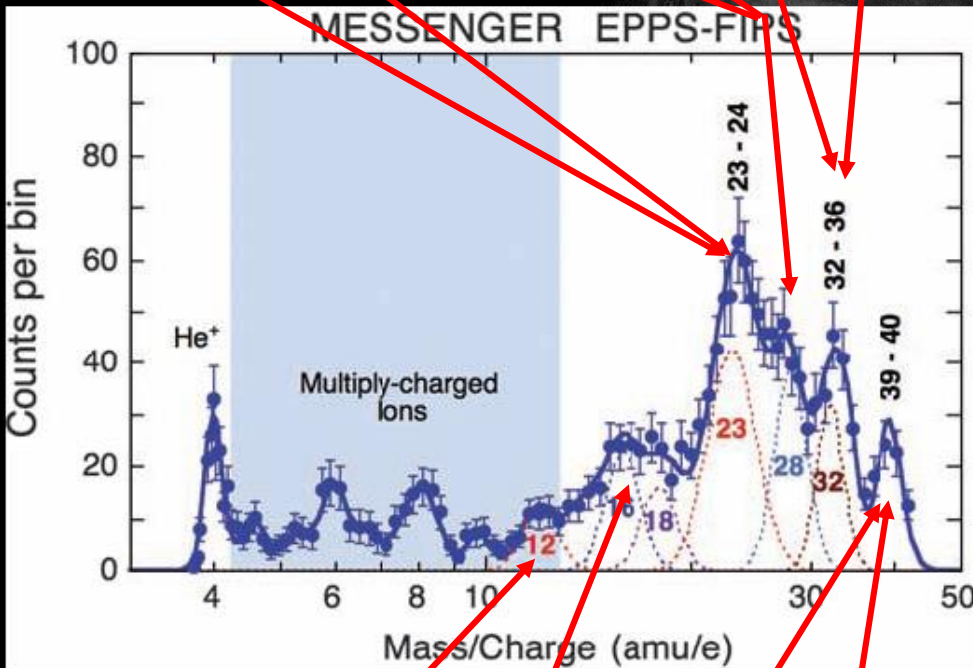
Exospheric signatures of surface composition and vice versa (Peplowski et al. 2014): GRS, XRS/MPO, PHEBUS, SERENA



Relations with the magnetosphere

- Relations between neutral and ion exospheres

Na^+ , Mg^+ , Al^+ , Si^+ , S^+ , Cl^+



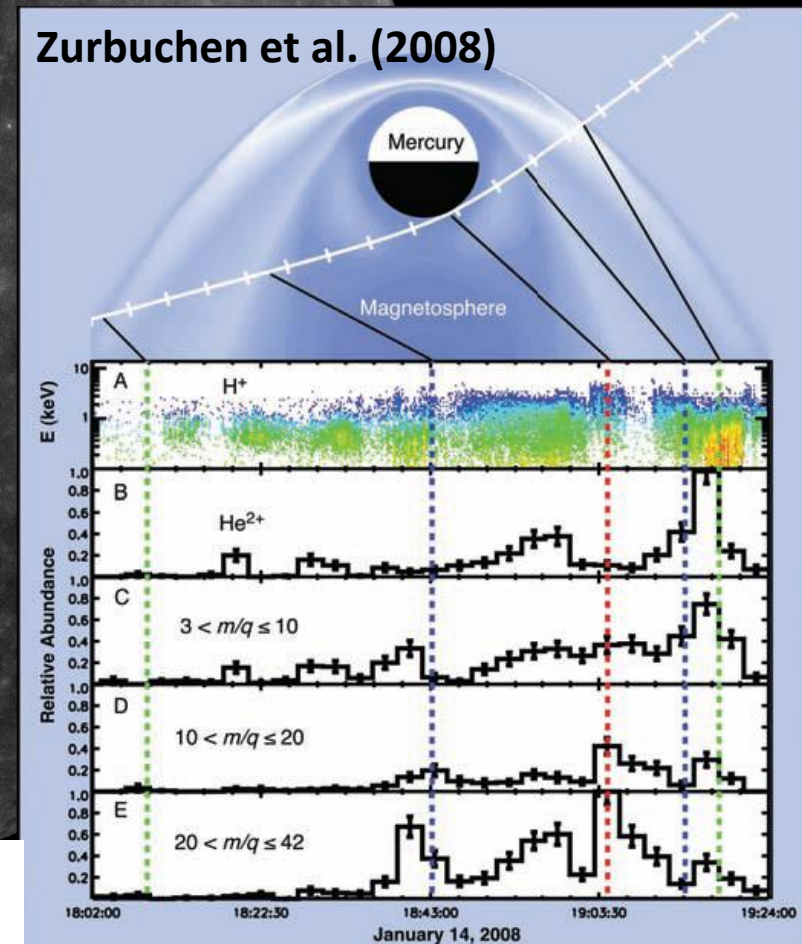
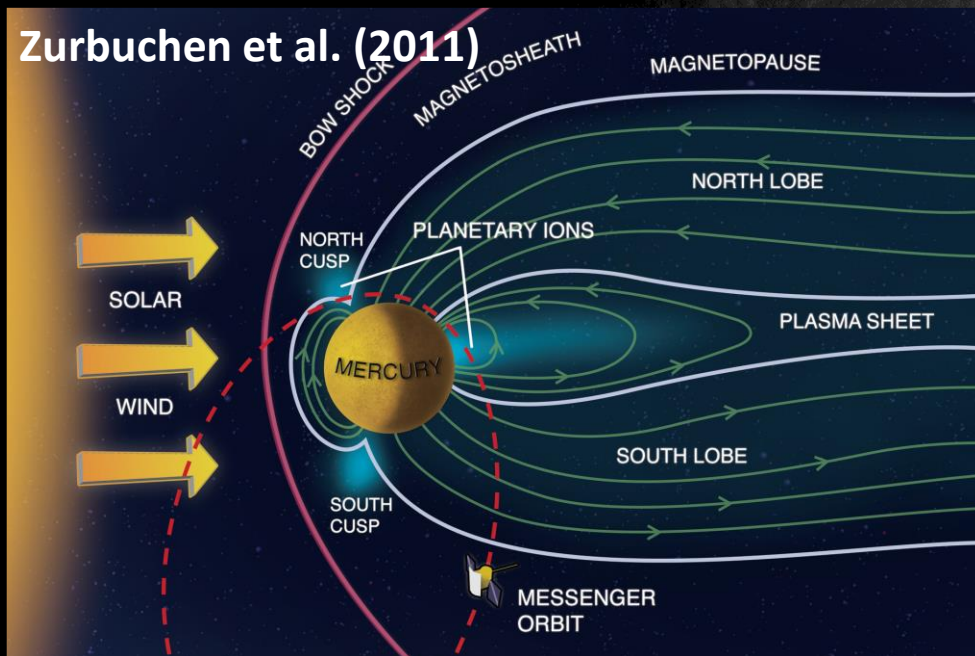
C^+ O^+ K^+ , Ca^+

Possibility to
combine ion
(PICAM/MPO,
MSA/MMO) and
neutral
(STROFIO/MPO)
mass spectrometers

FIPS & MAG

Relations with the magnetosphere

- Relations with magnetospheric structures
- With the magnetospheric boundaries/circulation...



Localization of the heavy ions density

FIPS & MAG

Few more questions after MESSENGER:

Why MESSENGER does not see a thermal Na component?

Why MESSENGER does not see a variable high latitude component?

Where do come from the high latitude peaks?

Escape rates? What are the sources of the exosphere? Endogenic or exogenic (dust, solar wind...)? Is Mercury eroded?

What are the origins of the Calcium? How can we maintain a Ca energetic exosphere?

Why don't we see O?

What are the signatures of sputtering? Ejection, surface radiolysis?

How Mercury surface is changed by the mechanisms leading to Mercury's exosphere?