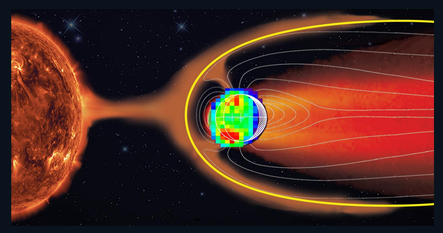
LABORATORY SIMULATION OF ION IMPACT AND BACK-SCATTERING ON MERCURY SURFACE ANALOGUES FOR PLANETARY SPACE WEATHER INVESTIGATION

A. Brin[1], G.Richards[1], E. De Angelis[1] , R. Rispoli[1], A. Milillo[1], M. Moroni[1], R. Sordini[1], L. Colasanti[1], N. Vertolli[1], F. Nuccilli[1], A. Milillo[1], A. Mura[1], V. Mangano[1], S. Orsini[1], C. Plainaki[2], S. Massetti[1] , C. Leto[2]

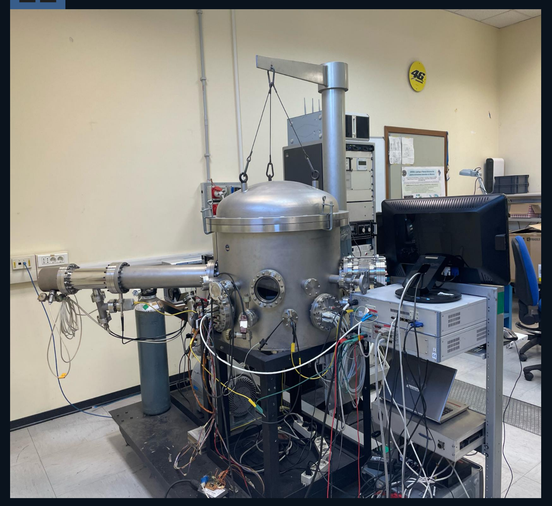
1. INAF-IAPS, Via del Fosso del Cavaliere 100, Rome, Italy; 2. ASI Agenzia Spaziale Italiana, Rome, Italy

The Ion and Energetic Neutral Atom (I-ENA) laboratory at INAF/IAPS facilitates controlled experiments on ion and neutral beam interactions with surface analogues and detectors for planetary space weather research [6]. It has supported missions such as Cluster, BepiColombo (SERENA), and novel program as Sweaters. The facility features a high-vacuum chamber (up to 10^{-7} mbar) and a charged particle source producing beams of 0–5 keV, adjustable in intensity, area, and direction. ELENA, the SERENA instrument devoted to the detection of backscattered ENAs together with solar wind or magnetospheric ions (10 eV–5 keV), is tested and calibrated using its Flight Spare in this laboratory [7]



Mercury's surface-bound exosphere mediates the transport of ionised and neutral species within the Hermean environment [1-3]. The interactions of the Solar wind with the regolith can induce sputtering, chemical reactions with surface species, or particle backscattering. The SERENA instrument onboard BepiColombo [4] is designed to investigate surface-exosphere-magnetosphere interactions using particle detectors and mass spectrometers. An example of these phenomena is the sodium emission from the surface caused by solar wind precipitation through the cusps, as shown in the adjacent figure (modified after [5]).

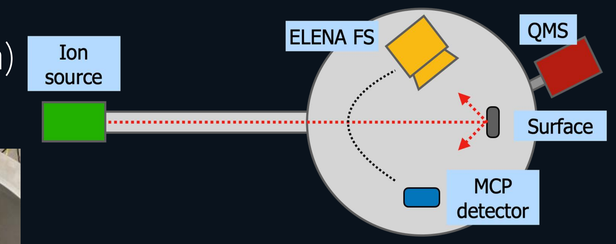
I-ENA LAB 1 FACILITY @ IAPS/INAF



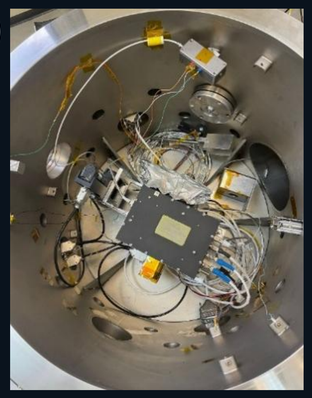
Vacuum system	*Pump system (scroll + turbopump) able to reach pressures up to* $10^{-7} mbar$
Ion beam	*IQP 10/63 Penning discharge type ion source with energy range of* $0 - 5\ keV$
Mass spectrometer	*Pfeiffer compact mass spectrometer with mass range* $1 - 200\ amu$
Gas species	*He/Ar*
Einzel lens system	*Adjustable beam intensity (range nA-mA)*
Beam parameters	*Spot size*: $2.5\ mm$ *(adujustable); Divergence: 0.76°*

SET-UP AND PRELIMINARY TESTS

a)

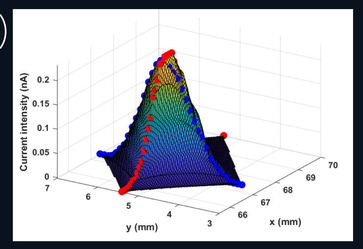


b)



c)

d)



a) Schematic of the experimental setup;
b) Top view of the experimental setup with ELENA placed behind the sample;
c) Meteorite analogue irradiated during the experiment;
d) Study of the 3d spatial beam profile used for bombardment.

The experimental set-up to investigate ion interactions with Mercury's surface consists of a ion source, a quadrupole mass spectrometer (QMS) and the ELENA FS. In collaboration with other teams, we plan to investigate a variety of diverse samples, including slabs of meteorite, and pellets similar in composition and grain size to Mercury's surface. INAF-IAPS teams, for the activity related to INAF Mini-Grant SIMILIS (*PI: Anna Galiano, Co-I: Fabrizio Dirri, Marco Ferrari*) will provide pre- and post-analysis of samples using VIS-IR spectroscopy at SLAB (Spectroscopy LABoratory at IAPS) and Raman spectroscopy to evaluate the effect of the bombardment.

Fluence: $4 \times 10^{14}\ ions/cm^2$

Exposure Time on Mercury: ~ 200 years (according to [8])

Mercury Analogue: Enstatite achondrite (Aubrite)

The experiment investigates sputtering and backscattering phenomena, improving our understanding of Mercury's environment and supporting the goals of the BepiColombo mission. In the first phase of the experiment, we will use standard detectors such as an MCP (Micro Channel Plate), RPA (Retarding Potential Analyzer), FC (Faraday Cup), and a mass spectrometer to analyse released particles. In the second phase we will set up the ELENA FS to analyse the direction of particles backscattered from the surface analogues during ion bombardment, providing ground truth to the ELENA experiment on BepiColombo .

References [1] Milillo A. et al. (2005) Space Science Reviews, 117 [2] Moroni M. et al. (2023) Icarus 401 [3] Mura A. et al. (2006) Advances in Geosciences: Volume 3:01 [4] Orsini S. et al. (2021) Space Science Reviews [5] Orsini S. et al. (2024) Scientific Reports 14.1: 30728. [6] Plainaki C. et al. (2016) J Space Weather Space Clim 6 A 31 [7] De Angelis E. et al. (2024) CNSP2024 meeting in Bormio [8] Leblanc F. et al. (2003) Icarus 164

Contact authors alessandro.brin@inaf.it - elisabetta.deangelis@inaf.it

Acknowledgment *This work has been supported by ASI*