



HAL
open science

OLYMPIA-LILBID: High Resolution Mass Spectrometry for the Calibration of Spaceborne Hypervelocity Ice Grain Detector

Arnaud Sanderink, Fabian Klenner, Jan Zabka, Frank Postberg, Jean-Pierre Lebreton, Illia Zymak, Gaubicher Bertrand, Bernd Abel, Ales Charvat, Barnabé Cherville, et al.

► To cite this version:

Arnaud Sanderink, Fabian Klenner, Jan Zabka, Frank Postberg, Jean-Pierre Lebreton, et al.. OLYMPIA-LILBID: High Resolution Mass Spectrometry for the Calibration of Spaceborne Hypervelocity Ice Grain Detector. 16th Europlanet Science Congress 2022, 2022, à renseigner, Unknown Region. 10.5194/epsc2022-1252 . insu-04089888

HAL Id: insu-04089888

<https://insu.hal.science/insu-04089888>

Submitted on 5 May 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License



OLYMPIA-LILBID: High Resolution Mass Spectrometry for the Calibration of Spaceborne Hypervelocity Ice Grain Detector

Arnaud Sanderink^{1,2}, Fabian Klenner², Jan Zabka³, Frank Postberg², Jean-Pierre Lebreton¹, Illia Zymak⁴, Gaubicher Bertrand¹, Bernd Abel⁵, Ales Charvat⁵, Barnabé Cherville¹, Laurent Thirkell¹, and Christelle Briois¹

¹LPC2E, UMR-CNRS 7328, Orléans, France

²Institute of Geological Sciences, Freie Universität Berlin, Berlin, Germany

³J.H. Institute of Physical Chemistry, Prague, Czech Republic

⁴ELI-Beamlines, Dolní Břežany, Czech Republic

⁵Leibniz-IOM, Leipzig, Germany

In 2005, a new type of mass spectrometer was commercialised for the first time, the Thermo Fisher Scientific OrbitrapTM. Using a Quadro-Logarithmic Electrostatic Ion Trap technology, Orbitrap mass spectrometers are able to reach ultra-high mass resolution¹. For a decade, the Laboratoire de Physique et Chimie de l'Environnement et de l'Espace (LPC2E) is developing a spatialised version of the Orbitrap, the CosmOrbitrap², to bring this high resolution in space exploration. The CosmOrbitrap is intended to be the mass analyser and acquisition system of laser ablation mass spectrometers aiming for planetary bodies like Europa or the Moon^{3,4}.

In this context, OLYMPIA - Orbitrap anaLYser MultiPle IonisAtion – has been develop to be used as a new laboratory test bench, and is adaptable to different ionisation methods. After a successful study of planetary atmosphere analogues using Electron Ionisation (EI)⁵, we now coupled OLYMPIA with the Laser Induced Liquid Beam Ion Desorption technique to analyse liquid water samples. For example, LILBID is able to accurately reproduce hypervelocity impact ionisation icy grains mass spectra⁶, such as those recorded by the Cosmic Dust Analyser⁷ (CDA) onboard Cassini in the vicinity of Saturn's icy moon Enceladus. The LILBID setup is usually coupled with a Time-of-Flight (TOF) mass spectrometer, with a mass resolution of ~ 800 m/ Δ m. By coupling the LILBID technique to OLYMPIA and its Orbitrap analyser, we are now able to record hypervelocity icy grains analogue mass spectra with ultra-high mass resolution. The setup is currently able to measure H₂O⁺ and H₃O⁺ ions with a mass resolution of around 150.000 m/ Δ m (FWHM), with the spectral appearance matching mass spectra of icy grains impact ionisation in an impact velocity range of 15 to 20km/s. Future work aims to simulate lower impact velocities below 15 km/s as they are typically expected for flyby or orbiter missions.

Those results will be implemented in the LILBID database⁸, and will be useful for the calibration and future data interpretation of the SURface Dust Analyser (SUDA) mass spectrometer⁹, which will be onboard NASA's Europa Clipper mission¹⁰ to characterize the habitability of Jupiter's icy moon Europa.

References

1. Makarov, A. Electrostatic Axially Harmonic Orbital Trapping: A High-Performance Technique of Mass Analysis. *Anal. Chem.* **72**, 1156–1162 (2000).
2. Briois, C. *et al.* Orbitrap mass analyser for in situ characterisation of planetary environments: Performance evaluation of a laboratory prototype. *Planet. Space Sci.* **131**, 33–45 (2016).
3. Arevalo, R. *et al.* An Orbitrap-based laser desorption/ablation mass spectrometer designed for spaceflight. *Rapid Commun. Mass Spectrom.* **32**, 1875–1886 (2018).
4. L. Willhite *et al.* CORALS: A Laser Desorption/Ablation Orbitrap Mass Spectrometer for In Situ Exploration of Europa, *2021 IEEE Aerospace Conference (50100)*, 2021, pp. 1-13, doi: 10.1109/AERO50100.2021.9438221.
5. Zymak, I. *et al.* OLYMPIA - a compact laboratory Orbitrap-based high-resolution mass spectrometer laboratory set-up: Performance studies for gas composition measurement in analogues of planetary environments. <https://meetingorganizer.copernicus.org/EGU21/EGU21-8424.html> (2021) doi:10.5194/egusphere-egu21-8424.
6. Klenner, F. *et al.* Analogue spectra for impact ionization mass spectra of water ice grains obtained at different impact speeds in space. *Rapid Commun. Mass Spectrom.* **33**, 1751–1760 (2019).
7. Srama, R. *et al.* The Cassini cosmic dust analyser. *Space Sci. Rev.* **Volume 114**, 465–518 (2004).
8. Klenner, F. *et al.* Developing a Laser Induced Liquid Beam Ion Desorption Spectral Database as Reference for Spaceborne Mass Spectrometers. *Earth and Space Science Under Review* (2022).
9. Kempf, S. *et al.* SUDA: A Dust Mass Spectrometer for Compositional Surface Mapping for a Mission to Europa. *European Planetary Science Congress 2014*, EPSC2014-229.
10. Howell, S. M. & Pappalardo, R. T. NASA's Europa Clipper—a mission to a potentially habitable ocean world. *Nat. Commun.* **11**, 1311 (2020).