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

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In 2005, a new type of mass spectrometer was commercialised for the first time, the Thermo Fisher Scientific Orbitrap™. Using a Quadro-Logarithmic Electrostatic Ion Trap technology, Orbitrap mass spectrometers are able to reach ultra-high mass resolution[1]. 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 CosmOrbitrap[2], 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 spectra[6], such as those recorded by the Comic Dust Analyser[7] (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/Δm. 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 H_2O^+ and H_3O^+ ions with a mass resolution of around 150.000 m/Δm (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 database[8], and will be useful for the calibration and future data interpretation of the SUrface Dust Analyser (SUDA) mass spectrometer[9], which will be onboard NASA's Europa Clipper mission[10] to characterize the habitability of Jupiter's icy moon Europa.

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