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DOTS: A High Resolution Orbitrap Mass Spectrometer for *In Situ* Analysis of the surface samples of Airless Planetary Bodies

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The dust detectors on board the Ulysses and Galileo spacecraft have shown that the Galilean satellites are surrounded by clouds of sub-micrometer size grains generated by impacts of interplanetary (micro-) meteoroids [1, 2]. *In situ* chemical analysis from orbit of these ballistic grains ejected from the surface of airless bodies provides a unique opportunity to remotely access the chemical composition of the Jovian moons' surface and subsurface. For Saturn, *in situ* identification by the Cassini Dust Analyzer (CDA) of sodium in icy grains in the E-Ring and in Enceladus plumes have proven a subsurface liquid water reservoir inside Enceladus [3, 4]. Noticeably, this was not accessible to other in situ or traditional remote sensing techniques. *In situ* measurements, either during a flyby or from orbit, of grains ejected from the surface, or emerging from the subsurface, of an airless body is a powerful tool to remotely study its surface composition and the nature of its geological activity. Crucial constraints on habitability can thus be determined. Our consortium of laboratories, in collaboration with Thermo Fischer Scientific [5, 6], is currently developing a high mass resolution Fourier Transform (FT) Orbitrap-based mass spectrometer optimized for *in situ* analysis of dust and icy grains in the environment of Solar System airless bodies. This new generation of dust mass spectrometer was studied in the framework of the Europa Jupiter System Mission (EJSM) instrument study in 2010-2012 and proposed in response to ESA's AO for the JUpiter ICy moons Explorer (JUICE) mission [7]. This mass analyser can provide very high mass resolution analysis ($M/\Delta M$ reaching 50 000 at m/z 50 Da). DOTS would allow identification of elemental and molecular species with excellent accuracy, in the 20-1000 Da mass range. In the context of the JUICE mission, DOTS would provide decisive information on the surface composition and on the putative liquid oceans in the subsurface of Ganymede, Europa and Callisto. The high mass resolution capability of DOTS is especially beneficial for heavy species, as the mass resolving power ($M/\Delta M$) of DOTS remains above 10 000 up to m/z=1 000 Da. Isotopic ratios can also be measured with DOTS, which would give insights into the origin and the processing of the parent molecules inside the grains. DOTS is designed with a dual polarity that allows for the detection of both negative and positive ions, best suited for both the detection of major rock forming elements (minerals, mostly cations) and organic compounds (preferentially anions in oxidizing medium). The recently discovered outer rings of Uranus [8] present striking similarity with Saturn's E ring, which is now considered as the result of ice volcanic activity of Enceladus. If a similar process is at work, this outer blue ring of Uranus could result from meteoroid impacts continually blasting dust off the surface of Mab (small embedded moon on the outermost blue ring) [9]. A DOTS-like instrument would be of great value to study the nature of this ring, in the context of a future mission to Uranus.

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