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Calibrating Impact Ionization Detectors for Hypervelocity Water Ice Grains from Ocean Worlds

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Abstract

Analyzing ice grains in space with impact ionization mass spectrometers, such as the Cosmic Dust Analyzer (CDA) on board the Cassini spacecraft, or in the future, the Surface Dust Analyzer (SUDA) on board the Europa Clipper spacecraft, provides crucial information about the ice grains' compositions and their sources (e.g. [1][2][3]). The impact speeds of the ice grains onto the metal target of the mass spectrometer can vary greatly and with it the conditions for ionization. The resulting mass spectra therefore vary significantly in appearance, even if arising from similarly composed grains. Spectra from slow impacts of approx. 5 km/s are generally dominated by ions from large water clusters, whereas impacts above approx. 15 km/s do not show clustering but fragmentation of the water molecules.

Here we report the accurate reproduction of mass spectra of water ice grains, as recorded with the CDA at typical impact speeds ranging between 4 km/s and 21 km/s, using a laboratory analogue experiment [4]. In this Laser Induced Liquid Beam Ion Desorption (LILBID) process, a µm-sized liquid water beam is intersected by a pulsed infrared laser at suitable energies and wavelengths. The created ions are subsequently analyzed in a time-of-flight mass spectrometer (TOF-MS) operating with the principle of delayed extraction [4].

Categorizing the flight mass spectra into five different speed regimes, we accurately reproduce the drastically varying spectral appearances by tuning the laser parameters and delay times of the gating system in front of the mass spectrometer [4]. The analogue experiment is capable of almost quantitatively reproducing CDA spectra of E ring ice grains from 4 – 15 km/s. Above that speed we achieve a qualitative match. The parameters for pure water ice grains from this 'speed calibration' of our experiment can now be applied to ice grains carrying a wide variety of non-icy compounds as observed in the E ring [1][2][3]. We are currently using this method for the development of a comprehensive spectral reference library, which will be a vital tool for investigating the composition of ice grains from mass spectra recorded at varying speeds by past and future impact ionization mass spectrometers.

References

[1] Postberg, F. Kempf, S., Schmidt, J., Brilliantov, N., Beinsen, A., Abel, B., Buck, U., and Srama, R.: Sodium salts in E-ting ice grains from an ocean below the surface of Enceladus, Nature, Vol. 459, pp. 1098-1101, 2009.

[2] Postberg, F., Khawaja, N., Abel, B., Choblet, G., Glein, C.R., Gudipati, M.S., Henderson, B.L., Hsu, H.-W., Kempf, S., Klenner, F., Moragas-Klostermeyer, G., Magee, B., Nölle, L., Perry, M., Reviol, R., Schmidt, J., Srama, R., Stolz, F., Tobie, G., Trieloff, M., and Waite, J.H.: Macromolecular organic compounds from the depth of Enceladus, Nature, Vol. 558, pp. 564-568, 2018.

[3] Khawaja, N., Postberg, F., Hillier, J., Klenner, F., Kempf, S., Nölle, L., Reviol, R., and Srama, R.: Organic compounds in Enceledean ice grains, Mon. Not. R. Astron. Soc. (under review), 2019.

[4] Klenner, F., Postberg, F., Hillier, J., Khawaja, N., Reviol, R., Srama, R., Abel, B., Stolz, F., and Kempf, S.: Analogue Spectra for Impact Ionization Mass Spectra of Water Ice Grains Obtained at Different Impact Speeds in Space, Rapid Commun. Mass Spectrom. (under review), 2019.