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Liquid Beam Ion Desorption Mass Spectrometry for Evaluating CASSINI Data

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Saturn's moon Enceladus emits plumes of ice particles from an area near its south pole which are detected and chemically analyzed by the Cosmic Dust Analyzer (CDA) on board the CASSINI spacecraft. Studying these ice particles provides unique insights into Enceladus geological properties. Technically the CDA is a time-of-flight mass spectrometer which delivers mass spectra of the particles and their fragments.
Since interpretation of the available CDA data is particularly challenging we employ a laboratory experiment to imitate experimental conditions in space.
Key part of our experimental setup is a micron-sized water beam in high vacuum. This beam is rapidly heated up by an infrared laser pulse, which is tuned to excite the OH-stretch vibration of water molecules. This causes the water beam to dissipate into small droplets, some of which carry a net charge even though the laser energy is well below the molecular ionisation energy. The charged droplets are then analyzed in a time-of-flight mass spectrometer.
With this experimental setup we successfully simulated the space born ice particles measured at Enceladus. By varying the laser intensity in our experiments, we can vary the amount of energy deposited in the liquid beam, and thus model different particle velocities. Also, variation of solute concentration in the water beam provides valuable information about ice particle composition. Some examples for anorganic solutes studied so far are sodium chloride, ammonia and hydrogen sulfite.
A special feature of our experimental technique is that desorption of particles from the liquid beam is particularly soft. This is explained by the fact that all laser energy is absorbed by the water molecules. In this way molecular bonds of solutes stay intact and molecular solutes are transferred into the droplet phase without getting destroyed. This is particularly interesting in the context of analyzing organic compounds - some of which have been detected at Enceladus.
Using the quantitative predictions our experiment delivers we could already support a model which proposes a liquid, salty ocean underneath the surface of Enceladus. The essential combination of liquid water and organic compounds makes the moon one of the sweet spots for possible extraterrestrial life in our solar system.