EPSC Abstracts
Vol. 6, EPSC-DPS2011-1502, 2011
EPSC-DPS Joint Meeting 2011

# Dust spectrometry in the Jovian system

**R. Srama**(1,2), S. Kempf (3), F. Postberg (4,2), J. Schmidt (5), H. Krüger (6), R. Thissen (7), Z. Sternosky (3), C. Engrand (8), K. Fiege (4,2), M. Horanyi (3), E. Khalisi (2), A. Mocker (2,1), G. Moragas-Klostermeyer (1,2), K. Otto (2), F. Spahn (5), V. Sterken (9,2), E. Grün (2,3), H. P. Röser (1)

(1) IRS, University of Stuttgart, Ger (2) MPI Nuclear Physics, Heidelberg, Ger (3) LASP, University of Colorado, Boulder, USA (4) University of Heidelberg, Ger (5) University of Potsdam, Ger (6) MPS, Katlenburg-Lindau, Ger (7) IPAG/PLANETO, Grenoble, F (8) CSNSM, Orsay, F (9) University Braunschweig, Ger

## Abstract

The Galileo spacecraft characterised the dust environment in the jovian system. The discoveries included an extended dusty ring system, the nano-metre sized stream particles originating from the moon Io, and the dust exospheres around the Galilean satellites Ganymed, Europa and Callisto [2]. The study of the nanodust-magnetosphere interaction and the compositional analysis of dust particles ejected by the surfaces of Ganymed or Europa offer unique future opportunities. New dust instrumentation is a factor of 10 more sensitive then the former Galileo detector and adds compositional analysis for moon surface studies complementary to neutral gas or ion particle investigations. A dust spectrometer performs complementary measurements with respect to neutral gas or ion investigations and is highly sensitive for organic, salty water ice and mineral particles.

## 1 Spectrometry of Satellite Surfaces

Orbiting the gas giant Jupiter, the icy satellites Ganymede and Europa are believed to harbour subsurface liquid water reservoirs between their ice crusts and silicate cores [3]. Because liquid water is believed to constitute an essential prerequisite for the emergence of life, ESA and NASA are currently discussing possible missions to explore these geologically active satellites in depth.

The analysis of solid material from the surface as well as from the interior of the moons is of great value in constraining the nature of processes below the surfaces of geological active moons. This was impressively demonstrated by Cassini's exploration of Saturn's icy moon Enceladus, which has been found to have an active gas and dust plume erupting from its south polar terrain. The impact mass spectrometer of Cassini's dust detector CDA [5] detected small amounts of sodium salts contained in the ejected ice grains [4], which stem from dissolved minerals from the moon's warm rocky core which is in contact with a reservoir of liquid water located at the south pole region [7]. This remarkable finding provides direct evidence, which could not been obtained by remote sensing techniques, for a liquid subsurface water reservoir.

Impacts of fast meteroids on the moon's surface produce ejecta particles which populate tenuous, approximately isotropic clouds around the moons. In-situ measurements by Galileo [2] and according calculations [1] showed an extended dust cloud of a few moon radii. Thus, an impact mass spectrometer on a spacecraft in a close orbit around the moon will detect a substantial number of ejecta. It will be able to perform an in situ compositional analysis of the moon's surface.

The parameters of the dust exospheres around the Galilean satellites were discussed in [1]. Parameters are the ejecta mass yield Y, the ejecta mass production rate $M^{+}$, the surface fraction of silicates $G_{sil}$, the slope of the ejecta speed distribution $\beta$, and the number density $n_d$ of ejecta $\geq 0.5\ \mu$m at altitude r. Furthermore, $r_e$ describes the impact rate of ejecta $\geq 0.5\ \mu$m onto a dust spectrometer with an effective sensitive area of 73 $cm^2$ on a spacecraft satellite orbiting the moon at an altitude r at speed $v_d$ . The flux and speed of the interplanetary meteoroids was determined to be $F^{\infty} = 7.6 \cdot 10^{-16}$ kg $m^{-2}s^{-1}$ and $v^{\infty} = 9$ km $s^{-1}$. The derived values for the dust number densities at an altitude of 100 km above the surface are $2 \cdot 10^{-2}$ $m^{-3}$ for Europa and $3 \cdot 10^{-4}$ $m^{-3}$ for Ganymed.

## 2. Dust Spectrometer

The Cassini Cosmic Dust Analyser (CDA) is an established TOF dust spectrometer currently characteris-

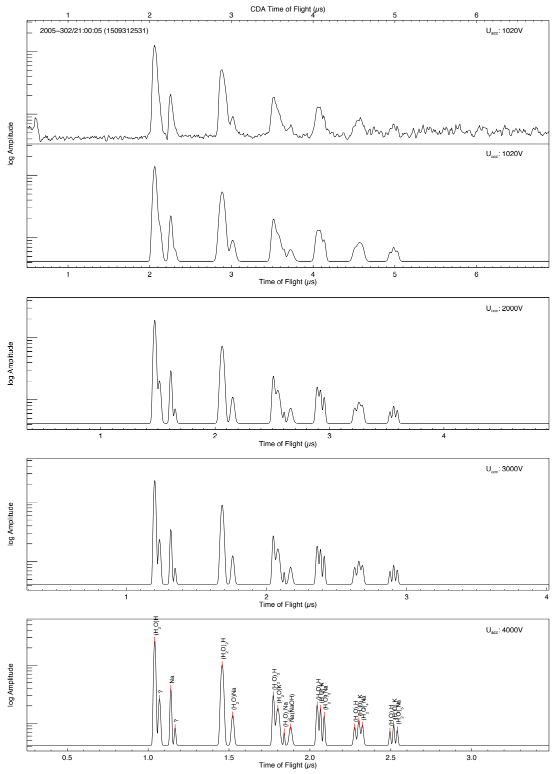

Figure 1: Water ice spectrum recorded by CDA on 2005-302 in orbit 17 when Cassini crossed the faint E-ring with a relative velocity of 4.3 km $s^{-1}$ to prograde circular dust particles. The uppermost panel compares the CDA spectrum with the spectrum's fit. The three lower panels show the same spectrum as if it were recorded with CDA with acceleration potentials of 2000, 3000, and 4000 V.

ing the Saturnian environment [5]. New concepts were developed in order to improve the mass resolution by keeping a simple instrument design. Such a spectrometer is scalable in size and an instrument mass of 4 kg provides sufficient sensitive area. The mass resolution of CDA is improved significantly by applying new instrumental parameters as shown in Fig. 1. The top signal represents the raw data and the other lower panels show processed spectra or spectra recorded with higher acceleration voltages. Therefore even a linear TOF spectrometer based on the CDA design with minor changes will provide major improvements. Even better performce is expected from more complex spectrometer designs using reflectron-type spectrometers or orbitrap technology (Fig. 2). A combination of an orbitrap system within a dust spectrometer with a mass resolution of approximately 50.000 is currently studied [6].

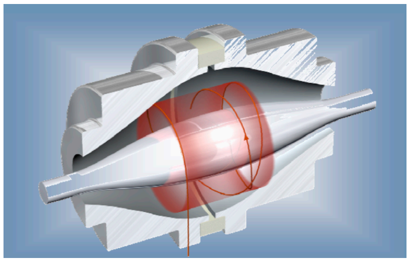

Figure 2: Orbitrap spectrometer with a mass resolution of up to 100.000 and a sensitive of approximately 10 ions.

# References

[1] Krivov et al., Impact-generated dust clouds around planetary satellites: spherically symmetric case. Plant. and Space Sci. 51, 251-269, 2003.

[2] Krüger, H., Krivov, A., Hamilton, D., Grün, E., Detection of an impact- generated dust cloud around ganymede. Nature 399, 558âĂŞ560 (1999).

[3] McCord et al. Hydrated Salt Minerals on Ganymede's Surface: Evidence of an Ocean Below, Science 292, 1523-1525, 2001.

[4] Postberg et al. Sodium salts in E-ring ice grains from an ocean below the surface of Enceladus, Nature 459, 1098-1101 (2009).

[5] Srama et al. The Cassini Cosmic Dust Analyzer. Space Science Reviews 114, 465-518 (2004).

[6] Thissen, R. et al. Ultra high resolution Fourier Transform mass analyzer for space exploration: Orbitrap. European Planetary Science Congress 2009 764 (2009).

[7] Zioslotohve, M.Y. An oceanic composition on early and today's Enceladus. Geophysical Res. Lett. 34, 23203, (2007).