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A Dust Spectromer for JUICE

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), J. K. Hillier (4), M. Horanyi (3), E. Khalisi (2), A. Mocker (2,1), G. Moragas-Klostermeyer (1,2), 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. 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 than the former Galileo detector and adds compositional analysis for moon surface studies complementary to neutral gas or ion particle investigations. A dust spectrometer is highly sensitive for organic, salty water ice and mineral particles. This paper focuses on instrumental aspects of this investigation.

Introduction

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 and according calculations 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 Krivov et al. (2003). The derived values for the dust number densities generated by interplanetary impactors 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. These values assume a sensitive impact area of only 73 cm^2 and considers ejecta particles with sizes ≥ 0.5 μm.

Dust Spectrometer

Two instrument options are proposed as a Dust Spectrometer for the JUICE mission. The first concept is a linear TOF mass spectrometer similar to the highly successful Cassini Cosmic Dust Analyser but with improved mass resolution (Fig. 1). The instrument has a sensitive area of 300 cm^2 and a drift length of 30 cm providing a mass resolution of up to 150. A cover protects the instrument from contaminations during the assembly and launch phase. The spectrometer analyses the speed, mass, charge and composition of individual dust impacts with a mass range between 1 and 1000 dalton which allows the detailed investigation of complex organic molecular cluster ions from individual dust impacts. The instrument mass is lower than 4 kg and the power consumption lies between 7 and 11 W depending on the final instrument configuration.

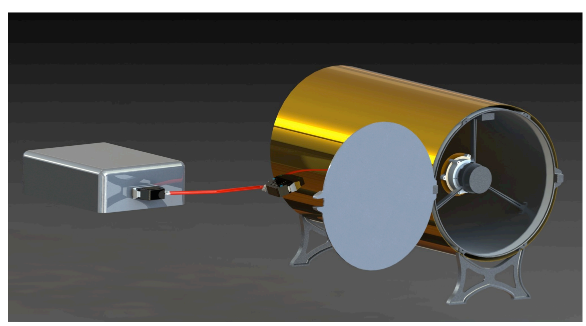

Figure 1: Dust Telescope for JUICE with an integrated linear TOF mass spectrometer.

The second concept is a reflectron-based spectrometer. Dust spectrometers using a reflectron were already flown onboard Stardust but this new design combines a large ring-shaped target with a high mass resolution.

Hyper-velocity impact tests in the laboratory showed mass resolutions up to 400. The instrument parameters mass and power remain almost constant.
Further improvements of the mass resolution are possible by the integration of an orbitrap system as ion detector in both types of spectrometers, the linear and the reflectron based instruments. An orbitrap spectrometer system provides a mass resolution of up to 100.000 and a laboratory model was already successfully tested.

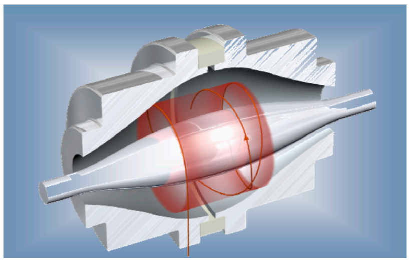

Figure 2: Orbitrap spectrometer with a mass resolution of up to 100.000 and a sensitivity of approximately 10 ions.