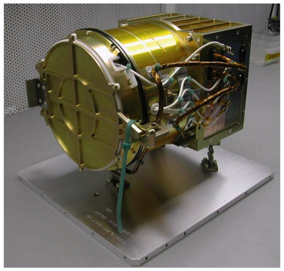

LDEX⁺: Lunar Dust Experiment with Chemical Analysis Capability to search for Water

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Abstract: The lunar dust environment is expected to be dominated by submicron-sized dust particles released from the Moon due to the continual bombardment by micrometeoroids, and due to plasma-induced near-surface intense electric fields. The Lunar Dust EXperiment (LDEX) is designed to map the spatial and temporal variability of the dust size and density distributions in the lunar environment onboard the upcoming Lunar Atmosphere and Dust Environment Explorer (LADEE)mission. LDEX is an impact detector, capable of measuring the mass of dust grains with m ≥ 1.7×10^{-16} kg (radius $r_g \geq 0.3$ µm), in a 50 km altitude circular orbit about the Moon. LDEX will also measure the collective current of the dust grains that are below the detection threshold for single dust impacts; hence it can search for the putative population of grains with $r_g \sim 0.1$ µm lofted over the terminator regions by plasma effects. LDEX has been developed at LASP and has a high degree of heritage based on similar instruments on the HEOS 2, Ulysses, Galileo, and Cassini missions. The LDEX engineering model (*top left image)* has been successfully tested and calibrated at the Heidelberg dust accelerator facility. The ***LDEX***⁺ instrument is being developed for a possible LADEE follow-up mission to add the capability for the in-situ chemical analysis of the impacting dust particles in order to verify the existence of water ice on the lunar surface.

The lunar dust environment: The two expected sources of dust in the lunar environment are (**Figure 1**): a) ejecta production due to continual bombardment by interplanetary meteoroids, and b) lofting due to plasma effects.

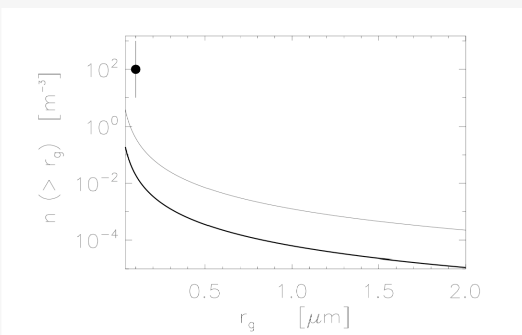

Figure 1. The expected number density of the ejecta cloud as function of particle radii at an altitude of 50 km, based on dust measurements near the Galilean moons of Jupiter (Krüger *et al*., *Icarus 164*, 170, 2003). Moderate ejecta production yield (Y~500, thick black line) and high yield (Y ~ 10 000, grey line) cases are plotted. The dot shows the dust density of the lunar dust exosphere, derived from Apollo observations of the solar corona above the lunar terminator (McCoy, *Proc. Lunar. Sci. Conf. 7*th, 1976; Postberg *et al* ., *Planetary and Space Sci*., in press, 2010)

LDEX instrument is an impact ionization dust detector with a sensor area of ~ 0.01 m2, derived from the heritage of the dust instruments operating on HEOS 2, Galileo, Ulysses, and Cassini. LDEX is a low risk, compact instrument with no deployable or moving parts, and uses no flight software (Figure 2). In addition to individual dust impacts of grains with radii $r_g > 0.3$ μm, LDEX can identify a large population of smaller grains ($0.1 < r_g < 0.3$ μm) by measuring their collective signal. LDEX resource requirements are summarized in Table 1. The expected impact rates, and the signature of lofted small grains expected over the terminators are shown in Figure 3.

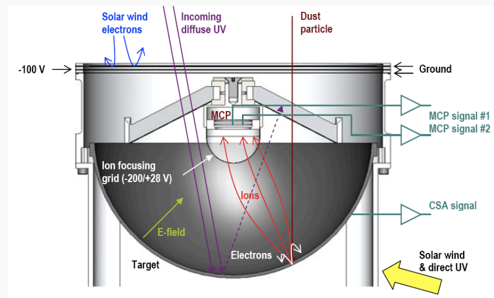

Figure 2. *LDEX* schematics.

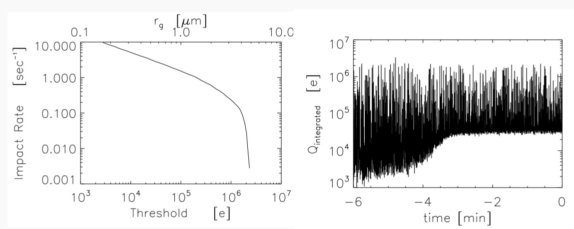

Figure 3. *left:* The expected impact rate on LDEX from meteoroid impact generated ejecta particles ($r_g > 0.3$ μm). *right:* The expected 'collective' signal from lofted grains during LADEE's approach of the terminator ($0.1 < r_g < 0.3$ μm).

Table 1. *LDEX* resource estimates.

Resource	Current Best Estimate	Margin [%]
Mass [kg]	3.6	15
Power [w]	3.7	36
Downlink [Mbits/day]	64	32
Volume [cm³]	15x15x20	N/A

LDEX⁺ ***instrument*** extends the *LDEX* capabilities to also measure the chemical composition of the impacting particles with a mass resolution of M/ΔM > 30. Traditional methods to analyze surfaces of airless planetary objects from an orbiter are IR and gamma ray spectroscopy, and neutron backscatter measurements. A complementary method to analyze dust particles as samples of planetary objects from which they were released. The source region of each analyzed grain can be determined with an accuracy at the surface that is approximately the altitude of the orbit. This 'dust spectrometer' approach provides key chemical and isotopic constraints for varying provinces on the lunar surfaces**.** ***LDEX***⁺ **is of particular interest to verify from orbit the presence of water ice in the permanently shadowed lunar craters.**

LDEX⁺ combines the impact detection capabilities of LDEX with a linear time-of-flight system, similar to the Cassini Cosmic Dust Analyzer (CDA) instrument. Figure 4 shows the schematics of ***LDEX***⁺ . Figure 5 shows an example time-of-flight mass spectrum of an ice-bearing dust grain.

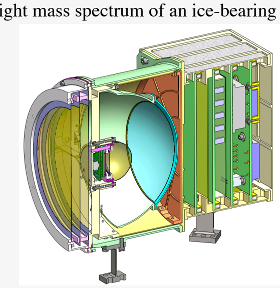

Figure 4. *LDEX*⁺ schematics. The target hemisphere is segmented to accommodate impact detection to determine the mass and speed of dust grains (top segment) and a time-of-flight setup for chemical analysis (bottom segment).

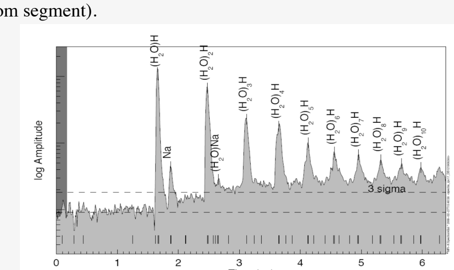

Figure 5. Spectrum of a water ice particle obtained at ~ 4 km/s impact speed by the Cassini CDA instrument in Saturn's E ring The dominant peaks are mass lines of water cluster ions $(H_2O)_nH^+$**,** generated upon impact of an ice-bearing particle.