NASA LUNAR SCIENCE INSTITUTE: COLORADO CENTER FOR LUNAR DUST AND ATMOSPHERIC STUDIES (CCLDAS)

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Introduction: The Colorado Center for Lunar Dust and Atmospheric Studies (CCLDAS) is one of the seven US teams of NASA's Lunar Science Institute. CCLDAS is focused on experimental investigations of the lunar surface, including dusty plasma and impact processes, the origins of the lunar atmosphere, and the development of new instrument concepts with a complementary program of education and community development. This presentation will show our most recent results: **a)** the completion of a 3 MV dust accelerator; **b)** the status of the Lunar Dust Experiment (LDEX) instrument development for the LADEE mission; **c)** small-scale supporting laboratory experiments; and **d)** the development of new instrument concepts for surface exploration of airless bodies.

The dust accelerator facility: A 3 MV Pelletron has been installed that contains a dust source, feeding positively charged particles into the large accelerator (Figure 1). The facility is used for impact experiments to study the production of secondary particles, plasma and neutrals, crater formation, and for the testing and calibration of dedicated dust instruments, for example. We will present the technical details of the facility and its capabilities, as well as the results of our initial experiments for damage assessment of optical devices, and penetration studies of thin films. We will also report on the use of this facility for the testing and calibrating the LDEX instrument. We also discuss the opportunities to use this facility by the lunar, planetary, space and plasma physics communities.

Figure 1. The 3 MV dust accelerator installed in the CCLDAS Lunar Environment and Impact Laboratory. The accelerator is used to simulate the effects of dust impacts with speeds >> 10 km/s for micron sized projectiles. The facility will be also used to test and calibrate plasma and dust instruments, including the Lunar Dust Experiment (LDEX) for the LADEE mission. The facility is now operational and available for the lunar community for impact studies.

The Lunar Dust Experiment (LDEX): LDEX) is a dust detector instrument designed and built for the LADEE (Lunar Atmosphere and Dust Environment Explorer) mission (Figure 2). The goal of LDEX is to map the dust environment of the Moon from a ~ 50 km altitude orbit.

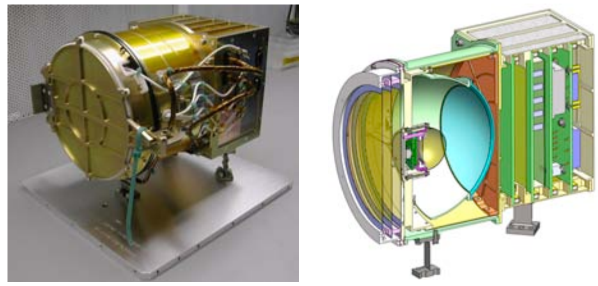

Figure 2. The LDEX engineering model (left), and its schematic diagram (right).

LDEX will measure the density and mass of dust particles. It is sensitive to individual impacts by particles > 0.25 micron in radius. Smaller particles can be detected in a cumulative mode, if present in sufficient quantities. LDEX is the first dust detector instrument optimized for operation while exposed to the UV environment above the sunlit lunar surface. The engineering model (EM) has been constructed and calibrated. The flight unit is currently under construction.

Small-scale laboratory experiments: These experiments are dedicated to the investigations of charging and mobilization of dust on surfaces. The effects of UV radiation, and the solar wind plasma flow. The most recent results address the effects of surface magnetic fields on the generation of intense, localized electric fields that are likely to play an important role in dust transport.

The Moon does not have a global magnetic field, unlike the Earth, rather it has strong crustal magnetic anomalies. Data from Lunar Prospector (LP) and SELENE (Kaguya) observed strong interactions between the solar wind and these localized magnetic fields. We use a horseshoe permanent magnet as an analogue to create a magnetic dipole field above an insulating surface in plasma. A complex potential distribution above the surface is observed. In our experiments, electrons are magnetized with gyro-radii r smaller than the distances from the surface d ($r < d$) and ions are un-magnetized with $r > d$. A non-

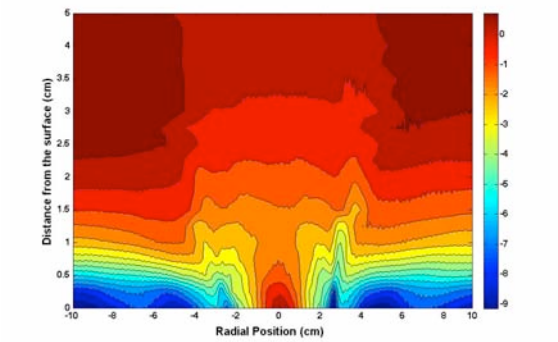

Figure 3. The potential distribution above a surface magnetic 'anomaly'. The color-code shows the measured values of plasma potential in Volts.

monotonic sheath is shown above the surface in the central magnetic dipole. Unlike negative charging on surfaces by electrons with higher mobility, potential on the surface in the central dipole is found slightly more positive than the bulk plasma potential because the surface charging is dominated by the cold un-magnetized ions while the electrons are magnetically shielded away. A potential minimum is found in the shielding region between the surface and the bulk plasma, most likely caused by the electrons that access the region due to the collision and are mirror-trapped between the two magnetic cusps. The value of the potential minimum with respect to the bulk plasma potential decreases with increases in the plasma density and the neutral pressure due to a spreading spatial density distribution in the sheath caused by the collisions. Potential on the surface fluctuates in the radial direction along the central dipole field line.

New instrument concepts: The observations of the inward transport of interstellar dust and the outflow of near-solar dust provide a unique opportunity to explore the dynamics and transport of small charged particles throughout the heliosphere. The flux, direction and size-distribution of interstellar dust can be used to test our models about the large-scale structure of the heliospheric magnetic field, and its temporal variability with solar cycle. The measurements of the speed, composition and size distribution of the recently discovered, solar wind-entrained nano-dust particles hold the key to understand their effects on the dynamics and composition of the solar wind plasma. Both the inflowing interstellar grains and the out-flowing nano-dust particles can be measured onboard a near Earth spacecraft at 1 AU, using modern dust detection techniques. The recently developed Dust Telescope (DT) instrument will be discussed, including its capabilities to measure the mass, charge, velocity vector, chemical and isotopic composition of the impacting dust particles, enabling the unambiguous identification of interstellar and interplanetary particles of various origin.

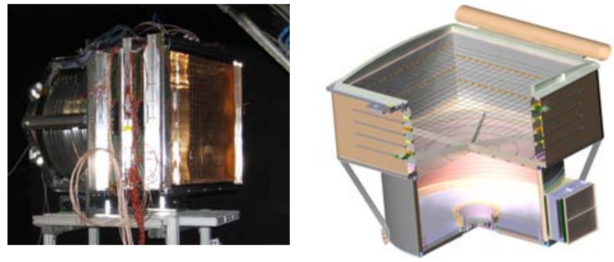

Figure 4. Laboratory model of a dust telescope (left) combining a trajectory sensor, and an impact dust detector the measure the mass, velocity, chemical and isotopic composition of interplanetary and interstellar dust. The schematic drawing of this instruments (right).

These measurements will provide an unexplored opportunity to link the heliospheric, space, planetary and astrophysics communities. We will also discuss the science requirements, instrumentation, and implementation options of this mission that could be achieved either by a small spacecraft orbiting the Moon, or by landing a payload on the lunar surface. As part of a landing package DT could be used as a modern version of the Lunar Ejecta and Meteorite experiment (LEAM) of the Apollo 17. DT could be used to detect the putative population of the slow-moving highly charged lunar dust particles, in addition to the flux and composition of interplanetary and interstellar dust bombarding the lunar surface.

References: http://lasp.colorado.edu/ccldas