The Dust Accelerator Facility of the Colorado Center for Lunar Dust and Atmospheric Studies

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Introduction: The Colorado Center for Lunar Dust and Atmospheric Studies (CCLDAS) is focused on: a) experimental and theoretical investigations of dusty plasma and impact processes; b) the development of new instrument concepts for future in situ dust and plasma measurements on the surface and in orbit about the Moon; and c) a complementary program of education and community development. CCLDAS addresses basic physical and applied lunar science questions, including the long-term usability of mechanical and optical devices on the Moon. CCLDAS is supporting the development of the Lunar Dust Experiment (LDEX), an in situ impact dust detector to be flown on the Lunar Atmosphere and Dust Environment Explorer (LADEE) mission scheduled to be launched in 2013.

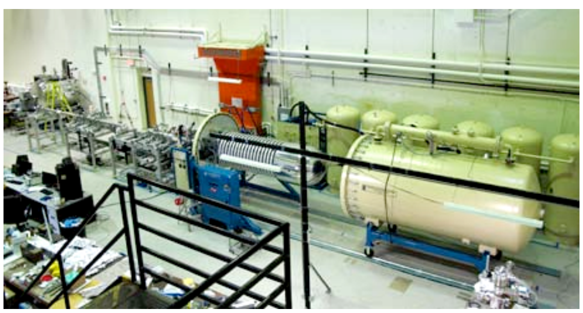

Figure 1. The 3 MV dust accelerator installed at in the CCLDAS Lunar Environment and Impact Laboratory. The accelerator is used to simulate the effects of dust impacts with speeds >> 10 km/s for micron sized projectiles. The facility will be also used to test and calibrate plasma and dust instruments,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

A major part of the CCLDAS experimental program is the construction of a 3 MV dust accelerator. The objective of the facility is to accelerate micron-sized grains, which will provide a unique research tool to generate high-velocity dust impacts, closely reproducing the effects of micrometeoroid impacts onto the lunar surface. The impact laboratory/facility, including the accelerator itself and the accompanying target chambers, will be capable of simulating the lunar surface environment, including variable plasma conditions, solar wind, UV radiation, and dust impacts (Figure 1). The facility is housed in the high-bay of the University of Colorado Nuclear Physics Laboratory, which previously housed a cyclotron accelerator.

Technical Details of the Accelerator: A dust source is mounted inside the Pelletron to inject highly charged dust particles for acceleration. After exiting the high-voltage (HV) stage, the particle transits through an electrostatic focusing lens, and then through a set of pick-up detectors for the initial determination of the charge, mass and velocity. A particle selection unit utilizes a set of HV deflection plates to reject particles outside the desired mass and velocity range from entering the experimental chamber. A final pick-up detector confirms the particle's arrival. Two interchangeable dust sources have been fabricated and tested, with one now installed in the Pelletron. All other critical components to the accelerator are now fabricated, tested, and in place in the operating accelerator. This includes the electrostatic lens (Einzel-type) for focusing the beam, and the first version of the particle selection unit (PSU) to divert from the dust beam all particles outside a preset range of mass and velocity. The impact experiments can be done in variety of configurations, including a large vacuum chamber (48 inches in diameter and 60 inches long), and an ultra-high-vacuum chamber both being outfitted with an array of diagnostic tools (Figure 2).

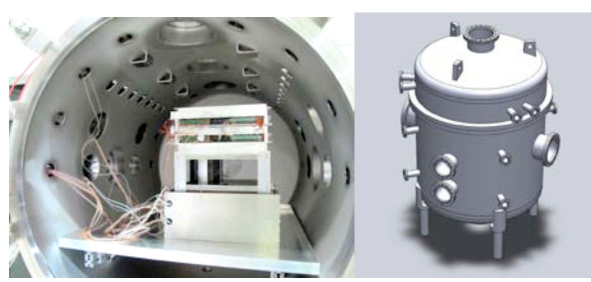

Figure 2. The Lunar Environment and Impact Laboratory chamber exterior (left) housing a dust-trajectory instrument for testing. This impact chamber will house UV, electron, and ion sources to simulate the variable plasma conditions on the lunar surface, and will act as a target chamber for the dust accelerator. The UHV chamber (right), designed for experiments of impact products, where ultra-high vacuum conditions are required.

Initial Experiments: The first experimental campaign has consisted of a continuous effort of performance improvements to the accelerator in tandem with a variety experiments which take advantage of the unique capabilities of the facility, including instrument developent, cratering studies, and detailed characterization of impact processes.

Performance improvements following initial operation of the acclerator include the development of a real-time beam profiler, which can enable one-to-one mapping of hypervelocity grains with their impact sites, as well as operational improvements to the beam quality during experiments. A second effort in progress is the development of an FPGA-based particle selection unit with integrated noise filtering, which will dramatically improve the signal-to-noise of the in-flight pickup detectors and will thus raise the upper limit on velocity detection.

Instrument-related studies have begun to investigate impact damage effects on the surfaces of next-generation lunar retroreflectors, impact effects on the SiN windows of the Solar Probe Plus instrument, characterization of thin-foil stacks for dust detection, and calibration of the LDEX instrument for the LADEE mission.

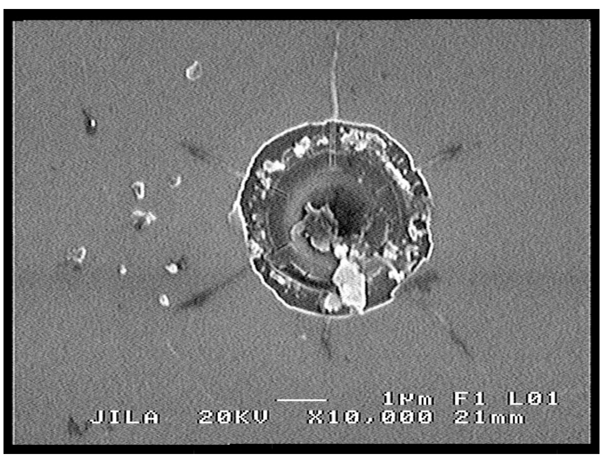

Figure 3. Scanning electron microscope image of an impact crater from hypervelocity impact onto fused quartz sample.

Cratering studies have been performed on a variety of solid materials and thin films, in order to investigate the damage from hypervelocity impacts in detail, including the excavation charaeteristics and the impact residue (Figure 3). These studies are coupled to a series of in-situ investigations of impact products such as secondary ejecta, neutral gas, and impact-generated plasma.

In this presentation, we provide an overview of recent and ongoing experiments at the accelerator, as well as opportunities for the larger lunar, planetary, space and plasma physics communities to use this new facility.