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Laboratory study of hyper-velocity impact-driven chemical reactions, impact ionization, and surface evolution in icy surfaces

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Although ice is prevalent in the solar system and the long-term evolution of many airless icy bodies is affected by hypervelocity micrometeoroid bombardment, there has been little experimental investigation into these impact phenomena, especially at the impact speeds seen in fly-by spacecraft or on airless icy surfaces. For example, there have been no experiments to date to determine the survivability and detectablility of complex organic chemicals in impact ionization time of flight mass spectrometry on fly-by spacecraft, such as the upcoming SUDA instrument on the Europa Clipper. Furthermore, there is little direct information about how dust impacts alter local surface chemistry, and dust impacts may be an important mechanism for creating complex organic molecules necessary for life. Laser ablation and light-gas gun experiments simulating dust impacts have successfully created amino acid precursors from base components in ice surfaces, but this has yet to be achieved with actual dust impact. Additionally, the Cassini mission revealed CO_2 deposits in icy satellites of Saturn, which may have been created by dust impacts. With the creation of a cryogenically cooled ice target for the dust accelerator facility at the NASA SSERVI Institute for Modeling Plasma, Atmospheres, and Cosmic Dust (IMPACT), it is now possible to study the effects of micrometeoroid impacts in a controlled environment under conditions and at energies typically encountered in nature. Complex ice-target mixtures are created with a flash-frozen target which allows for homogeneous mixtures to be frozen in place even with salt mixtures that otherwise would form inhomogeneous ice surfaces. Coupled with the distinctive capabilities of the IMPACT dust facility, highly valuable data concerning the evolution of icy bodies under hypervelocity bombardment and the genesis of complex organic chemistry on these icy bodies can be gathered in unique and tightly controlled experiments. This cryogenic ice target will also be used in conjunction with a new, separate apparatus which will accelerate submicron sized icy dust particles to velocities > 5km/s. The upcoming facility employs a commercial electrospray ionization source to generate highly charged icy particles of the desired composition, and linear accelerator techniques will be used to achieve relevant velocities. This new facility will enable (1) the direct investigation of impact ionization of icy dust particles and how it can be used for habitability assessment of the Icy Worlds and the search for life, and (2) test and calibrate in situ instrument from ongoing and future missions. Results from a variety of recent and ongoing investigations will be presented.