LABORATORY EXPERIMENTS ON ASTROPHYSICAL DUST ANALOGS AT NASA/MSFC. E. Todd. Bradley[1], A. Eric Cantrell[2], Dennis. L. Gallagher[2], Sakurako Kuba[3] [1]Florida Space Institute, University of Central Florida, Orlando,FL, eric.bradley@ucf.edu, [2]Marshall Space Flight Center, Huntsville, AL, [3]University of Alabama Huntsville, AL

Introduction: Dust grains are ubiquitous within the solar system both spatially and temporally. Spatially, dust can be found throughout the solar system where its composition and physical properties are affected by the varying temperature and radiation environment. Temporally, dust plays a fundamental role in the formation of planetary systems and continues to broadly affect processes from the transport of material on icy moons and Saturn's rings to dust storms on Mars and levitation/transport of dust on the Earth's moon. Our solar system formed from dust created in a supernova and gases that were part of a collapsing nebula. Most of that material gathered at the center and became our Sun where gravity and mass sparked the nuclear fusion that keeps us warm today. Explaining everything else remains a challenge. Did the nebula gas condense onto the dust at different rates depending on the type of gas and the temperature? Did electric charging of the dust and ice by the young Sun's ultraviolet light contribute to the condensation of gas onto the dust? Understanding these basic processes are at the root of answering some of NASA's most fundamental questions of how our solar system formed (captured under NASA's first Strategic Goal). Today, icy grains of dust are spewed from geysers on Enceladus and Europa, which affects the surrounding environment. Small dust grains in Saturn's rings are thought to be charged and therefore transported along magnetic field lines. Charged dust grains in Martian dust are thought to discharge and produce lightning, which fosters interests in both the science and engineering communities. Apollo astronauts noticed a haze above the lunar surface that turned out to be levitated charged dust grains. These processes drive much of the robotic and human exploration in, on, and in between the planets in our solar system

Facility: The Dusty Plasma Laboratory (DPL) contains two dust traps. This first operates at room temperature with a long history of research dealing with micron-sized levitated dust grains and aerosols for the Earth and Moon. After decades of research with this facility, experienced MSFC scientists and engineers conceived a second dust trap equipped with a 1) helium cryostat to cool the dust grain or aerosol and 2) a gas feed system to condense gas onto the grain (Fig. 1). These two innovations enable research dealing with the charging and light scattering properties of individual dust, aerosols, and ice grains throughout the solar system and into the interstellar medium. This provides ground truth for advancing NASA's science and engineering objectives that are used to define future NASA missions.

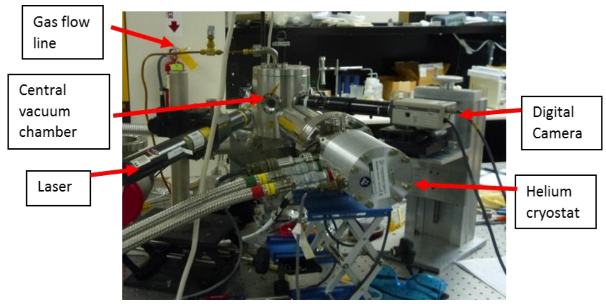

Figure 1. Electrodynamic balance (EDB) facility with heilium cryostat and gas feed system.

Past Projects: Investigations using the EDB at room temperature was used to perform experiments on dust grains. The properties of aerosols, rotation rates of non-spherical dust grains and the charging properties of laboratory and returned lunar samples were studied using this facility and are well documented [1, 2].

Current Projects: We are currently investigating the charging of simulated Martian dust grains, which is poorly understood but has both scientific and engineering applications. The physics of electrostatic dust charging may be responsible for lightning thought to be associated with Martian dust devils (Fig. 2). Electrostatic charging of dust is certain to increase the hazard for landers, equipment, and astronauts that will drive the development of mitigation strategies, which can be guided from DPL measurements.

Figure 2. Martian dust devil imaged by the NASA Mars Reconnaissance Orbiter (Image credit NASA, JPL)

We are currently investigating the growth of icy grains in the lab at temperatures relevant to Saturn's rings (Fig. 3) and icy moons such as Enceladus as well as Jupiter's icy moon Europa. This research has profound implications for science questions dealing with the transport of charged ice in the outer solar system and engineering questions dealing with high priority NASA missions to Europa or other "water worlds" that have the potential for supporting life. The "standard" method for investigating dust and ice is to examine bulk properties for thousands of grains laying on a substrate, which most likely has different properties from those of a single dust grain.

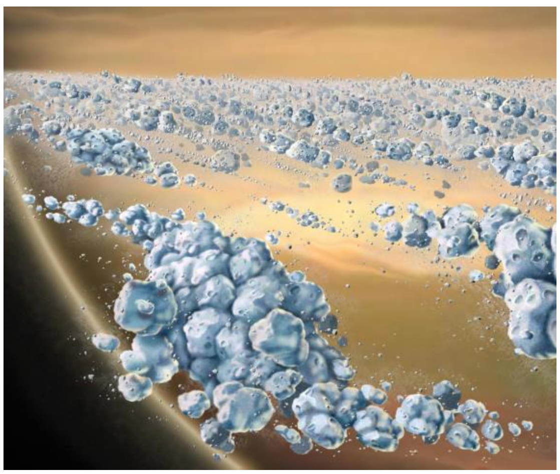

Figure 3. Illustration for Saturn rings showing large particles that are covered by a regolith of icy grains. (Image credit: NASA, JPL)

Future Projects: Conditions can be replicated in our facility to study aerosols for bodies with appreciable atmospheres such as Saturn's moon Titan. As photons or charged particles hit Titan's atmosphere ions and electrons are produced that trigger a chain of chemical reactions producing hydrocarbons (Fig. 4). Eventually aggregates of these hydrocarbons lead to aerosols, which have been seen in the lower layers of haze around Titan [3]. We can study various stages of aerosol formation and growth by measuring the charging properties, light scattering behavior, and morphological changes as the aerosol evolves.

The condensation rates of gas onto grains in the interstellar medium is critical to understanding the early formation of the solar system, to which we can expect to contribute uniquely. The New Horizons Mission has already obtained data for the Pluto system and is headed for the Kuiper belt. Figure 5 shows an artist's impression of a Kuiper belt object where primordial debris is thought to be pristine material from the early formation of the solar system. DPL ground truth measurements can help with the interpretation of observations of these distant objects and also solar system formation theories.

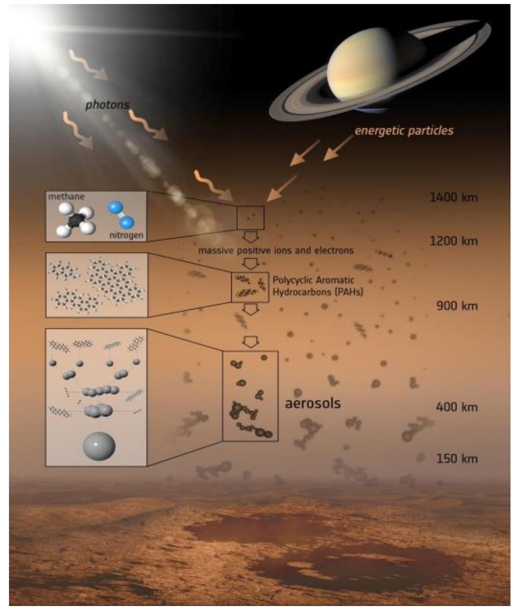

Figure 4. Various steps that lead to the formation of the aerosols that make up the haze on Titan (Image credit: NASA, JPL)

Figure 5. Artist's impression of a Kuiper Belt object at the outer rim of our solar system. (Image credit: NASA, Goddard)

References:

[1] Spann J et al. (2001) Physica Scripta, T89, 147-153. [2] Abbas et al. (2010) The Astrophysical Journal 718, 795-809. [3] Lavas et al. (2011) The Astrophysical Journal 728, 80.