Laboratory Experiments on Astrophysical Dust Analogs at NASA/MSFC

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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 and transport of dust on the Earth's moon. Understanding these basic processes are at the root of answering some of most fundamental questions of how our solar system formed. 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. The 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.

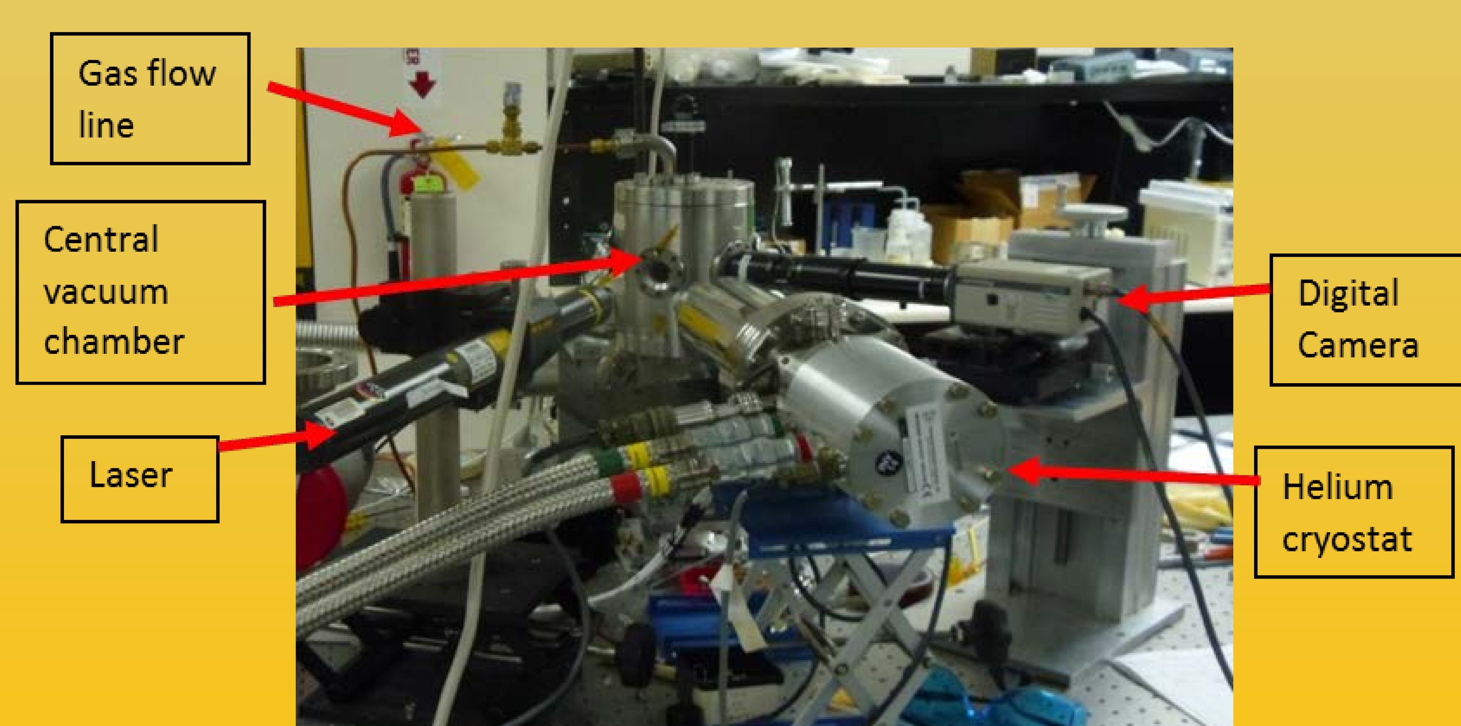

Figure 1. Electrodynamic balance (EDB) facility with helium cryostat and gas feed system.

Current Projects

We are currently investigating the charging properties of simulated Martian dust grains, which is poorly understood but has both scientific and engineering applications (Fig 2). We are also 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.

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

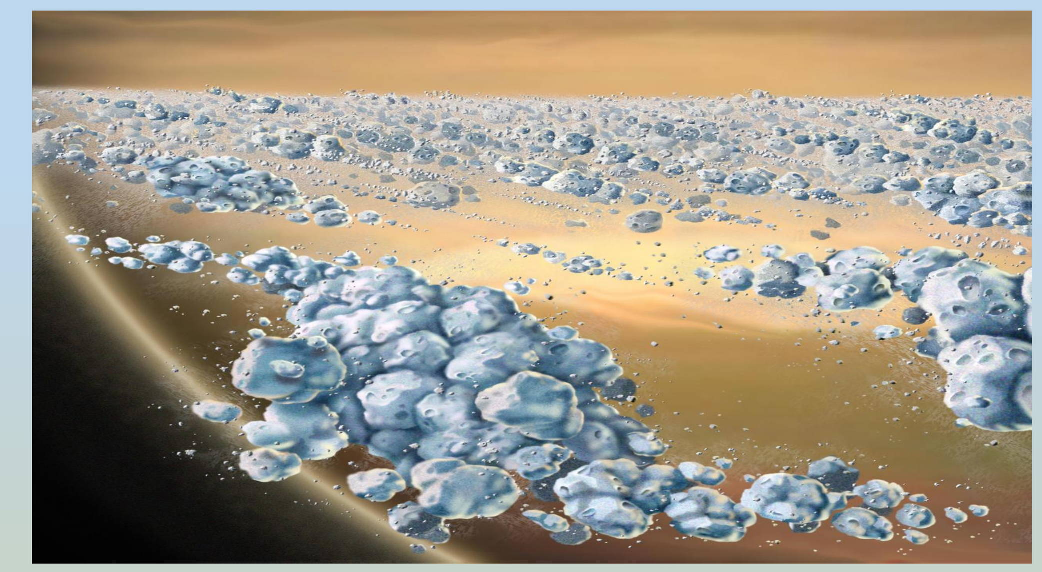

Figure 3. Illustration for Saturn rings with large particles covered by a regolith of icy grains. (Image credit: NASA, JPL)

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 hydro-carbons lead to aerosols, which have been seen in the lower layers of haze around Titan. The condensation rates of gas onto grains in the interstellar medium is critical to understanding the early formation of the solar system (Fig. 5), to which we can expect to contribute uniquely. DPL ground truth measurements can help with the interpretation of observations of these distant objects and also solar system formation theories.

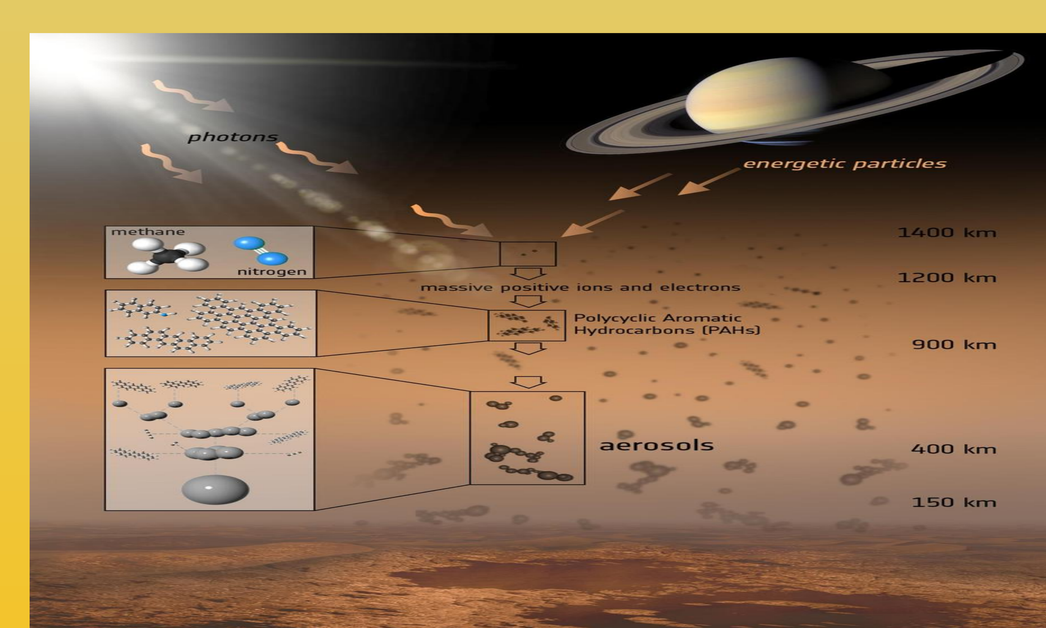

Figure 4. Various steps that lead to the formation of the aerosols that make up the haze on Titan (Image credit: NASA, JPL)

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