Engineering primary configuration was a pair of retarding potential analyzers. Several different plasma sensor configurations were used. The theoretical charge produced in the impact plasma is on the order of 1 µm in size. The speed is determined by the electric fields that could arise from lunar surface charging or conductive coating. The targets were electrically biased to represent trodynamic forces as they travel around Saturn.

Typical dust impacts on Saturn’s moons range from slow impacts of particles moving at the Keplarian orbital speed up to a relative speed of 20 km/s from particles that have been accelerated by Saturn’s co-rotating magnetic field. Those particles are on the order of 1 µm in size. The speed is determined by the change to mass ratio of the particle, which dictates the balance between gravitational and electromagnetic forces [Spyre et al., 2008b; Hild & Muto, 2012].

Upon impact, the dust particle and part of the impact surface are vaporized and partially ionized, forming a plasma, as depicted in Figure 1. This impact plasma can have very different characteristics depending on the impact speed and on external fields due to surface charging at the impact point. As a result, the contribution from hypervelocity impacts to the plasma environment around each moon can be quite different.

Hypervelocity Impact Experiments

In order to study the composition of hypervelocity impact plasmas, we conducted experiments at the Max Planck Institute for Nuclear Physics using a Van de Graaff dust accelerator. Iron projectiles were electrostatically accelerated to speeds of 3–66 km/s and impacted on target materials including metallic (tungsten) and glassy surfaces. The glassy materials included solar cells and optical solar reflectors, with and without a conductive coating. The targets were electrically biased to represent external fields that could arise from lunar surface charging or from the ambient plasma.

Our tests were conducted at pressures below 10⁻¹³ mbar, corresponding to an atmospheric mean free path longer than the chamber diameter and allowing for free expansion of the impact plasma, similar to conditions in space. Figure 2 shows the mass and speed range of the iron projectiles, color-coded for the theoretical charge produced in the impact plasma. Impact events on the targets were observed by optical, radio frequency, and plasma sensors, as arranged in Figure 3. Inverse dust plasma sensor configurations were used. The primary configuration was a pair of retarding potential analyzers (RPA), shown in Figure 4, positioned at 63 and 85 mm from the impact point.

Impact plasma production has been previously studied, resulting in an empirical power-law relation for electromagnetic forces [Spyre et al., 2008b; Hild & Muto, 2012]. Upon impact, the dust particle and part of the impact surface are vaporized and partially ionized, forming a plasma, as depicted in Figure 1. This impact plasma can have very different characteristics depending on the impact speed and on external fields due to surface charging at the impact point. As a result, the contribution from hypervelocity impacts to the plasma environment around each moon can be quite different.

Figure 2: Hypervelocity impact plasma generation and expansion. Shown here is the case of a positively charged surface, which imposes an electric field that separates the plasma species.

Plasma Expansion Model

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