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Suborbital Particle Aggregation and Collision Experiment (SPACE)

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Abstract

1. Introduction

The Suborbital Particle Aggregation and Collision Experiment (SPACE) is a novel approach to study the collisional properties of sub-millimeter-sized, highly porous dust aggregates.

The experiment is expected to help increasing our knowledge about the processes dominating the first phase of planet formation. During this phase the growth of planetary precursors occurs by agglomeration of micrometer-sized dust grains to aggregates of a few tenths of a millimeter. However, the formation of larger bodies from the so-formed building blocks is not yet fully understood. Recent numerical models especially lack support by experimental studies in the size range of sub-millimeter-sized bodies colliding at very gentle relative velocities of below 1 cm/s.

2. SPACE on REXUS

The SPACE experiment will fly on the REXUS (Rocket Experiments for University Students) suborbital rocket within the March 2012 flight campaign. REXUS is a joint DLR (German Aerospace Center) and SNBC (Swedish National Space Board) project, launching two suborbital rockets each year from Esrange (European Space and Sounding Rocket Range), Kiruna, Sweden. University students like the SPACE team get the opportunity to fly their experiment in one of the rocket's experiment modules.

With a total flight time of about 15 min and an apogee at ~ 100 km, the REXUS rocket offers between 90 and 180 s of free-fall time. The rocket spin at lift-off is reduced by releasing two Yo-Yo masses [1], so that the residual acceleration induced by spinning gets down to 10^{-3} *g*.

The SPACE experiment uses this reduced gravity phase to observe multiple collisions between sub-millimeter sized dust particles at very low relative velocities (below 1 cm/s) which cannot be reached in the laboratory.

3. Experimental Set-Up

To observe the dust-aggregate collisions, the SPACE experiment holds dust particles inside particle containers that are back-lit by an LED array and records the movement of these particles with a high-speed camera [Figure 1]. The experimental set-up comprises four particle containers, allowing the variation of particle parameters between the containers and thus enhancing the data gathered.

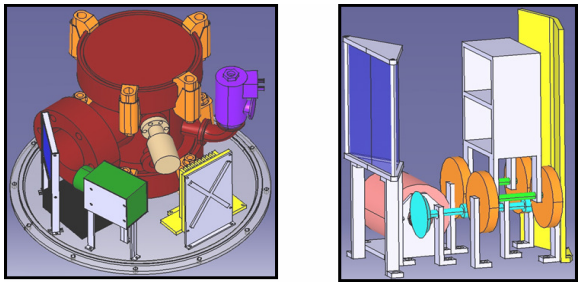

Figure 1: Set-up of the SPACE experiment. Left: Experiment components fitting on the REXUS experiment module bulkhead: vacuum chamber (brown) with its clamps (orange), pressure sensor (beige), vacuum valve (purple), high-speed camera (green) with its control computer and data storage system (yellow) and mirror (blue). Right: Experiment components inside the vacuum chamber: particle containers' frame (grey box), prism (light blue), LED array (yellow), motor (pink) and 2D-shaking mechanism (turquoise, orange and green).

To assure that the collisional behavior of the particles is not influenced by the presence of gas, the particle

containers are placed inside a vacuum chamber which is evacuated during the experimental run.

A bent in the LED array and a prism placed between the particle containers and the camera allow for a 3D-view of the particles.

As the residual spin acceleration of the rocket might influence the free movement of the dust aggregates, a 2D-shaking mechanism actuated by a motor agitates the particle containers.

4. Expected Experimental Results

The data gathered by the SPACE experiment will directly feed a dust growth and collision model [2] by delivering new information on the collisional behavior (sticking or bouncing) of porous sub-millimeter sized dust aggregates at very low relative velocities.

As the particle containers will hold a great number of dust aggregates, we also hope to observe multiple particle collisions leading to clustering [Figure 2].

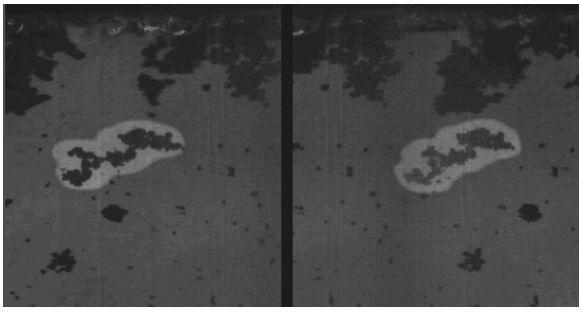

Figure 1: Clustering of millimeter-sized porous dust particles (highlighted) seen from two views separated by 30°. This image was recorded during the second drop-tower campaign of the MEDEA (Microgravity Experiment on Dust Environments in Astrophysics) experiment in November 2010 [3].

First observations of particle collisions with the SPACE experiment will be recorded during a drop tower campaign at the Bremen drop tower in August 2011 and presented at the European Planetary Science Congress in October.

References

[1] EuroLaunch:, REXUS User Manual (2010)

[2] Güttler, C. et al.: The outcome of protoplanetary dust growth: pebbles, boulders, or planetesimals? I. Mapping the zoo of laboratory collision experiments, Astronomy and Astrophysics, 513, A56, 2010

[3] Weidling, R., Güttler, C., Blum, J.: Free Collisions in a Microgravity Many-Particle Experiment. I. Dust Aggregate Sticking at Low Velocities, eprint arXiv: 1105.3909, submitted to ICARUS, 2011.