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Laboratory measurements on the mechanical properties of Saturnian ring particles

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1. Introduction

Saturn's main rings are predominantly composed of almost pure water ice particles in the size range of ~ 1 centimeter up to ~ 10 meters. The ring constituents frequently collide at very low collision speeds of only a few millimeters per second. However, these gentle encounters result in the formation and vanishing of significant structural variations in the rings as observed by the *Cassini* and the *Voyager* missions.

Several numerical simulations have been carried out to study the evolution of the ring structures, but the result of computational studies may also depend on their input parameters. Typical input parameters for the simulation of particle collisions are the coefficient of restitution and the specific surface energy. The former is given by the ratio of center-of-mass velocities after and before a collision, and is a measure of the dissipation of kinetic energy in encounters. The latter determines the strength of interparticle forces, and thus is a critical value for the "stickiness" of the collision partners.

2. Surface force measurements

We will present a novel experimental setup for the measurement of the interparticle forces between macroscopic water ice particles in a cryogenic high-vacuum environment. From these measurements the specific surface energy can be derived directly. The setup consists of a high-vacuum chamber, hosting a cryogenic cooling apparatus that can be cooled down to temperatures of ~ 85 K. A cantilever with a resistance strain gauge attached to it and with one of the samples placed on it's tip is mounted inside the cooling mechanism, whereas the second sample is directly attached to a cold plate. By moving the cantilever using a nano-positioning stage the samples can be separated gently and the pull-off force can be measured. The respective surface energy can be derived using e.g. Johnson et al.'s theory [1].

3. Collision experiments

Additionally, we designed an experimental setup capable of colliding a large number of 1-cm-sized water ice particles at very low relative velocities of only a few millimeters per second [2]. From a measurement campaign in the microgravity environment of the Bremen drop-tower facility we obtained numerous binary collisions providing information about the energy loss in mutual collisions.

The collisions were performed at temperatures of ~ 100 K and were captured using two synchronized high-speed cameras. They were mounted at an angle of 45° to provide three-dimensional trajectory information for all ice particles. The colliding particles are tracked and the coefficient of restitution can be obtained from their trajectories.

We will present recent results from both of the above mentioned experimental studies and their implications for the simulations of Saturn's dense main rings.

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References

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