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Collisions of (sub-)mm size water-ice aggregates

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Abstract

The presence of water ice in solar system bodies is wide spread. In order to understand the formation of these objects better, laboratory experiments of water-ice aggregate collisions have been carried out to study their formation in protoplanetary disks.

1. Introduction

The first stages of planet formation are still under debate. Beyond the snow line, water-ice and other volatile components condense to solid state, allowing them to collide and – depending on the conditions – allowing them to stick together and to form larger aggregates. In order to understand the formation of icy objects like icy planets, asteroids and comets better, we carried out laboratory experiments. Collisions of ice aggregates about 100 µm up to 2 mm in size have been observed in the laboratory, and several parameters like velocities, spin frequencies of aggregates and their collision velocity have been measured. To produce interaction between these aggregates, they are forced to levitate through a physical phenomenon known as Knudsen compressor effect [1,2]. Because of the nature of this effect, the tiny icy bodies levitate and collide with each other, sticking and consequently forming bigger aggregates. The interaction of the ice aggregates is imaged with a long range microscope.

2. Knudsen Compressor effect

Let's suppose two closed chambers filled with air and connected to each other with a cylindrical tube like in Figure 1. Let' also suppose that the diameter of the tube is much higher than the mean free path of air molecules, then, the pressure of the two chambers will be always identical. But, if the diameter of the tube lies on the order of the mean free path of air, an overpressure on the warmer side is produced due a non-equilibrium thermodynamic conditions.

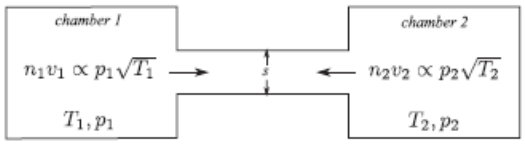

Figure 1: Two chambers at different temperature connected by a tube of diameter *s* [1].

It is believed that the ice aggregates' pores act like tubes producing an overpressure on the warmer side of the aggregate, leading to its levitation (Figure 2).

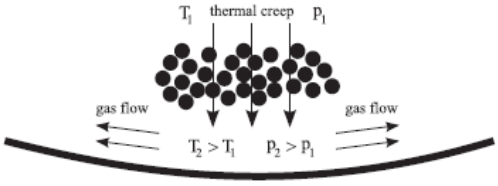

Figure 2: Ice aggregate levitation due to Knudsen compressor effect [1].

3. Summary and Conclusions

Results of the experiments will be presented. Studying collisions and taking into account effects like sublimation and possibly electrostatic charge, models on aggregate growth and destruction and therefore icy planet formation can be improved.

References

[1] Kelling, T. and Wurm, G.: Self-Sustained Levitation of Dust Aggregate Ensembles by Temperature-Gradient-Induced Overpressures, Phys. Rev. Lett., Vol. 103, 215502 (2009).

[2] M. Knudsen, Ann. Phys. (Leipzig) 336, 205 (1909).