The Particle Accretion in Microgravity Experiment: Protoplanetary Aggregate Formation

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Introduction

Early on during terrestrial planet formation processes in the gravity-less environment of the solar nebula the accretion of dust aggregates occurs, leading to the formation of protoplanetesimals. The exact mechanisms related to their growth poorly understood and in order to better inform planet formation models we need to understand certain properties of the aggregates that control their growth. The objectives of the experiments are to determine the effects of particle size, number density, and composition on the accretion of dust-scale grains in microgravity conditions. This work enhances and builds upon previous microgravity free-float experiments initially performed by astronaut Don Pettit aboard the International Space Station (Figure 1), and later performed by co-author Durda. In the Pettit experiments bags of finely grained materials like coffee and sugar were agitated and left to free-float immediately showing the aggregation of the highly cohesive materials.

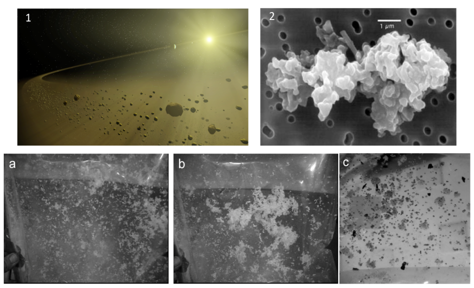

Figure 1: (1) Artist rendering of an early solar nebula. (2) SEM image of IDP dust aggregate of many small sub-micron particles. (a, b) Aggregates and individual particles of sugar and (c) other materials that were allowed to float for several hours aboard the ISS (a, b, c figures from Love et al 2014).

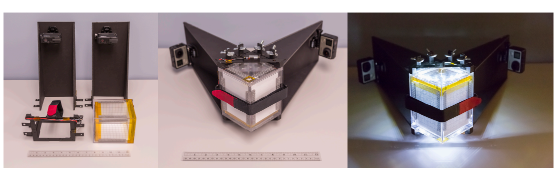

Figure 2: The experiment frame and camera arm mounts used in the parabolic flight experiments. GoPro's are mounted on each arm for a stereoscopic view. LED lights are activated during flight for extra illumination to observe the fine-grained dust's behavior.

Experiment

We built and flew a parabolic flight experiment to study the dependence of fundamental properties of different relevant analog minerals on the growth of porous clusters (aggregates) in microgravity (Figure 2). Each frame has two camera arms with GoPro cameras mounted on each end to collect data. In this experiment, we used olivine, UCF-1 CI simulant, enstatite, crushed Allan Hills 83100 CM2 carbonaceous chondrite and Northwest Africa 869 L3-6 ordinary chondrite.

Results and Conclusions

The aggregate pixel areas were determined and plotted for each frame, and for each of the experiment boxes. Interestingly, we observed the greatest aggregation in the smallest particle sizes and the CI simulant and ALH 83100 meteorite. Boxes containing higher number densities saw larger and more abundant aggregate formation. We find that the composition of the dust was not as important to aggregate formation as the particle size distribution (Figure 3), and to lesser degree, the number density in the initial cloud.

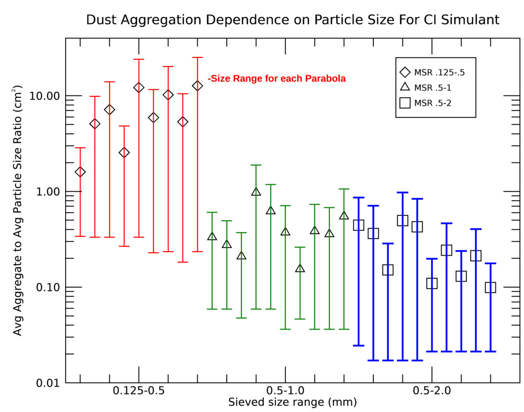

Figure 3: The average aggregate sizes obtained from the tracked clip image sequences and plotted in three bins according to their respective particle size distributions.