Introduction:

The standard model of planet formation proceeds from the gravitational collapse of an interstellar cloud of gas and dust through collisional accretion of solids into planetesimals and eventual runaway growth to form the terrestrial and giant planets [1]. A critical stage of that process is the growth of solid bodies from mm-sized chondrules and aggregates to km-sized planetesimals where gravity becomes an important force for further growth. Theories on this dust growth phase include gravitational instability [2,3] and direct binary accretion of particles [4]. To characterize the collision behavior of dust in protoplanetary conditions, experimental data is required, working hand in hand with models and numerical simulations. In particular in the range of mm- to cm-sized particles, the collection of a statistical data set on collision behavior will allow to better characterize the growth of dust to planetesimal sizes.

In order to replicate the very low collision velocities that the dust grains experience in the protoplanetary disk (PPD), this experimental data has to be collected under microgravity conditions. Classical platforms include parabolic aircrafts or suborbital rockets, both limited in the microgravity time available. With the rise of miniaturized payloads, we are now able for the first time to access long-duration microgravity using orbital platforms, such as the International Space Station (ISS) or stand-alone CubeSats, thus revolutionizing the experimental possibilities.

Microgravity Experiments on Dust Aggregate Growth:

Dust growth experiments date back to the late 90s where the hit-and-stick behavior of μm-sized grains demonstrated a possible mechanism for grain growth inside the PPD [5,6]. Later experiments on larger grains have shown that, at the relative velocities expected in the PPD [7], sticking upon collisions yields to bouncing and fragmentation [8]. Figure 1 shows a dust collision model integrating the results of a decade of experimental data [9].

The transition between grain sticking and bouncing remains relatively unexplored experimentally as very slow collisions of mm- and cm-sized particles can only be performed under microgravity conditions. Microgravity platforms used to perform these experiments include drop towers (up to 9 s of free-fall time in Bre-
Building on the success of the NanoRocks payload, the CMR is currently developing a 3U CubeSat to study collisions between cm-, mm-, and submm-sized particles. The CubeSat Particle Aggregation and Collision Experiment (Q-PACE) is a 3U satellite hosting an Experiment Test Cell (ETC) containing the particles, a camera to record the particle collisions, and all the avionics necessary to guarantee for the satellite’s autonomy during its time on orbit (Figure 3). The collected data will be transferred to the Q-PACE ground stations at UCF and the University of Arkansas. Q-PACE is currently in manufacturing and is scheduled to launch with Virgin Galactic’s ELaNa XX on December 1st, 2017.

We will present results from the NanoRocks experiment as well as the mission design of Q-PACE to demonstrate how orbital miniaturized payloads can be used to collect unprecedented amounts of data on the collision behavior of PPD dust grains.

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References: