FORSTERITE DUST AGGREGATION ABOARD THE INTERNATIONAL SPACE STATION (ISS). T. E. Koch[1*], D. Spahr[1], D. Merges[1], O. Christ[1,2], P.-T. Genzel[1], M. Lindner[1], B. Winkler[1] and F. E. Brenker[1]. [1]Goethe University Frankfurt, Institute of Geoscience, 60438 Frankfurt am Main, Germany, [2]University of Padua: Padova, Veneto, Italy. *t.koch@em.uni-frankfurt.de

Introduction: Particle aggregation plays a major role in different stages of planet formation. The formation of particle cluster aggregates is considered to be among the first processes leading to planet formation in the Solar Nebula [1,2] and amoeboid olivine aggregates and fluffy-type Calcium-Aluminum-rich inclusions, are thought to be formed by particle aggregation at an early stage [3,4]. Many chondrules have accreted a layer of dust, the so called fine grained rim [5]. However, there are many open questions regarding the size range, morphology, and sticking probability to understand these complex solar nebular processes in detail [1]. Electrostatic forces were proposed to affect the aggregation of dust particles and chondrules. First experiments have already shown the influence of electrostatic forces on the sticking behavior of particles [6, 7].

We carried out an experiment aboard the International Space Station ISS, which was primarily developed to examine chondrule formation [8]. As a positive side effect, we could study the aggregation behavior of dust particles in an electric field and their response to electric discharges. The observation of aggregation processes and the behavior of the particles after an electric discharge can potentially offer important constraints on of how particles behave after a shock wave or lightning propagated through the solar nebular.

Experiments: The experiment was carried out inside a 1.5 U NanoRacks NanoLab aboard the ISS from Nov 2018 to Jan 2019 [8]. The sample material consisted of well-characterized, polycrystalline, synthetic Mg_2SiO_4 forsterite dust particles with grain sizes between 80–130 µm [8]. The particles are angular with irregular shapes. The sample chamber was manufactured of optically transparent glass filled with Ar at 100 mbar pressure. W-electrodes were fused into the glass. The experiments were filmed with a Raspberry Pi Camera V2 using a frame rate of 40 fps. The trajectories and the resulting velocities of the different particles after ignitions were analyzed frame by frame. Due to the low frame rate, the particle velocities in the approx. first 10 frames were determined by the length of particle traces during an exposure.

Results: The first images recorded after the experiment commenced showed that the space between the electrodes was completely empty. Charging of the capacitor led to the appearance of a 2 × 2 × 4 mm sized aggregate. This aggregate must have formed prior to the start of the experiment. This aggregate probably contained all dust particles in the sample chamber. Low energetic electric discharges disintegrated some parts of the aggregate; however, the particles reunited within seconds. When the capacitors were charged to higher voltages, the stronger electric field caused an alignment of the particles along the field lines. The longest particle axis was thereby oriented parallel to the field lines. High energetic arc discharges accelerated the particles to velocities up to 60 mm s^{-1} with a subsequent exponential velocity decrease to < 5 mm s^{-1} within 0.5 s. The particles slowly returned to the space between the electrodes and the number of aligned particles decreased with ongoing discharges.

Discussion: Our experiment demonstrated that dust particles can form large, closely packed aggregates under microgravity conditions. The observed aggregate was relatively stable regarding low energetic discharges and sputtered particles returned immediately to the aggregate, which shows strong effect of attraction between the particles. The electric field between the electrodes led to the strong deceleration of fast particles. Furthermore, the strong electric field led to longitudinally alignment of the particles, which can decrease the packing density of aggregates compared to random oriented, heterogeneous-shaped grains. Preferred orientation of elongated crystals was e. g. observed in dust rims and matrix which was interpreted as an effect of low energetic shock waves [5,9], however we have shown that electric fields can also lead to orientation effects.

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References: [1] Wurm G. and Blum J. (1998) *Icarus 132*, 125–136. [2] Blum J. and Wurm G. (2000) *Icarus 143*, 138–146. [3] Krot, A. N et al. (2004) *Geochim. Cosmochim. Acta* 68, 1923–1941 [4] MacPherson, G. J. et al. (2005) *Chondrites and the Protoplanetary Disk 341*, 225–250. [5] Bland P. A. et al. (2011) *Nat. Geosci., 4* 244–247. [6] S. G. Love G. G. et al. (2014) *Meteorit. Planet. Sci.* 49, 732–739. [7] T. Steinpilz et al. (2020) *Nat. Phys.* 16, 225–229. [8] D. Spahr et al. (2020) *Icarus* 350. [9] Watt, L. (2006) *Meteorit. Planet. Sci.*41, 989–1001.