**FORMATION OF FUSED AGGREGATES ABOARD THE ISS WITH IMPLICATIONS FOR EARLY SOLAR SYSTEM PARTICLE AGGREGATION.** T. E. Koch[1], D. Spahr[1], B. J. Tkalcec[1], O. Christ[2], P.T. Genzel[1], D. Merges[1], F. Wilde[3], B. Winkler and F. E. Brenker[1,4]

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**Introduction:** Calcium-aluminum-rich inclusions (CAIs) are the oldest material of our Solar System [e. g. 1] and likely witnesses of early aggregation processes [e. g. 2–4]. Fluffy-type CAIs have very irregular, fractal structures and the question arises how they could survive transportation to the outer protoplanetary disk (PPD), chondrite aggregation and compaction. Melting events were considered to be involved in the formation of different CAI characterstics such as igneous type B CAIs, Wark-Lovering-rims and compound CAIs [3–6].

We developed an experiment which was carried out under long-term microgravity conditions aboard the International Space Station (ISS) to combine aggregation and thermal annealing of dust particles [9]. In the study presented here, we show the formation of aggregates using flash heating under microgravity conditions, which can be linked to the formation of refractory inclusions with regard to their morphology and microstructure.

**Experimental Set-up:** The experimental set-up was mounted inside a $10 \times 10 \times 15$ cm$^3$ sized container [9]. The sample chamber was manufactured from glass with a size of $\approx 2 \times 2 \times 2$ cm$^3$. Arc discharges with energies of 5–8 J and durations between 300 and 500 µs per discharge were induced and the experiments were filmed [9]. The initial sample material consisted of well-characterized synthetic forsterite particles in the size range of 80–130 µm [9].

**Methods:** The resulting aggregates were analyzed using synchrotron micro-CT, scanning electron microscopy (SEM) and electron back-scattered diffraction (EBSD) and morphologies were compared with those of natural CAIs in Northwest Africa (NWA) 13656, a CAI-rich CV3 chondrite.

**Results:** The fused aggregates can be divided into three groups regarding their morphology: (1) elongated aggregates consisting of ≈ 3 to 15 initial grains with a ratio of longest to shortest dimension of ≈ 2; (2) three winged boomerang-shaped fractal aggregates formed from ≈ 5–20 particles: and (3) aggregates with a bulk center of ≈ 5–20 fused particles. These three morphologies are similar to the natural fluffy-type CAIs observed in NWA 13656. The analysis of polished fractal aggregates showed that the particles have various degree of melting. Some aggregates show no melt intersection between the particles. Some particles in the aggregates are surrounded by igneous rims while the center of the grain remained unprocessed. EBSD revealed that the rims have a crystallographic preferred orientation with the [001] axis perpendicular to the surface. The bulk aggregates consist of fused particles with various degrees of melting. The high cooling rates and particle velocities determined for the single particles imply that the particles aggregated and fused in a very short time < 0.5 s.

**Discussion & Conclusion:** The morphologies of many aggregates strongly resemble the typical shapes of fractal fluffy-type CAIs. The particles probably collided still molten on the surface and solidified fast still in motion. The elongated aggregates show similar dimension ratios to natural CAIs [9]. Since these fractal structures have survived the long and turbulent transportation from the ISS to the Goethe University in Frankfurt, it is plausible that a small amount of melting may have supplied the required stability for natural fractal CAIs to have survived transportation to chondrule formation regions and aggregation to planetesimals.

The formation of the bulk aggregates by grain collision with different degrees of melting resembles observations in natural CAIs [4]. Igneous rims surrounding some of the resulting particles remind in thickness and crystal orientation of natural Wark-Lovering rims [10], however this requires further investigation since our experiment was limited to pure forsterite.. These results imply that localized (flash)-heating events with subsequent aggregation can form aggregates which show many different CAI characteristics.

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**References:** [1] Connelly J. N. et al. (2012) S*cience* 338, 651–655. [2] Dominik C. et al. (2006) *Protostars Planets V Rev.* 783–800. [3] Rubin A. (2012) *Meteoritics & Planetary Science* 47, 1062–1074. [4] Ivanova et al. (2015) *Meteorit. Planet. Sci.* 50, 1512–1528. [5] Aléon J. et al. (2013) *LPS XLIV*, Abstract #2530. [6] Wark D. and Boynton W. V. (2001) *Meteoritics & Planetary Science* 36, 1135–1166. [7] Spahr D. et al. (2020) *Icarus*. 350, 113898. [8] Koch T. E. et al. (2021) *LPS LII*, Abstract #1950. [9] Zhang M et al. (2021) *Meteorit. Planet. Sci.* 56, 500–514. [10] Bolser D. et al. (2016) *Meteoritics & Planetary Science* 51, 743–756.