**MELTING OF COSMIC SPHERULES.**

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**Introduction:** Cosmic spherules are dust particles of extra-terrestrial origin that are melted during entry into Earth's atmosphere. The flux of such particles to Earth is approximately 40,000 tons per year [1]. Cosmic spherules have either glassy or quenched textures. The process of melting depends on the initial characteristics of the dust particle, e.g., the initial velocity and angle of entry, and also on the precursor composition of the dust particle [e.g., 2]. When a dust particle is melted, the silicates are partially homogenized, while metals and metal sulfides are separated into a distinct core within the spherule [3]. If a spherule remains molten for a long enough period of time, the metal core will migrate to the edge and eventually escape the spherule due to momentum effects [3]. We report the analysis of cosmic spherules that exhibit various stages of melting and the imaging of the spherules by computer-assisted X-ray nanotomography (CT).

**CT Scans:** High resolution CT scans were acquired at the Ghent University in the Centre for X-ray Tomography, with voxel size of 2 µm. Scans were processed with the Octopus software package [4]. In total, 180 cosmic spherules and micrometeorites from Widerøefjellet, Sør Rondane Mts., Antarctica [5], with sizes from 200-800 µm, were scanned. Cosmic spherules with metal inclusions were examined in detail, and digital models were used to understand the evolution of melting of spherules.

**Results:** Cosmic spherules have a wide range of morphologies. When recrystallization has not occurred in cosmic spherules, silicate glasses tend to be near-spherical. However, some spherules appear oriented, with a flattened "front" and rounded to elongate "back." The position of metal cores within spherules is consistent with this type of orientation, with typical offsets of metal from the center of spherules in the direction of propagation.

Some spherules were observed with up to 6 metal inclusions, suggesting quenching prior to the aggregation of a metal core.

Some spherules are highly elongated. Two spherules were found with "dumbbell" morphology, with two spheres joined by a silicate bridge. Neither was found to have metal inclusions, and thus are considered to have remained molten long enough for metal to be lost. Both of the "dumbbell" spherules also are oriented, with flattened fronts and rounded backs.

Thus, despite the small size of cosmic spherules, these appear to remain oriented in the atmosphere. This is possible because the high initial velocity of the precursor leads to quick melting to an aerodynamic shape that is not altered by atmospheric perturbations before quenching. Once melting begins, the metals segregate and exit the silicate phase. If the spherule remains molten, a "dumbbell" shape can develop. Given enough time, this can develop into two separate spherules. In this way, an initially comparatively large dust particle can be disrupted into multiple glassy spherules as well as an I-type spherule.

**References:** [1] Maurette M. et al. 1991. *Nature 351,* 44-47. [2] Flynn G. 1989. 19th Lun. Planet. Sci.. Conf. 673-682. [3] Genge M. J. and Grady M. M. 1998. *Met. & Planet. Sci.* 33, 425-434. [4] Dierick M. et al. 2004. *Meas. Sci. Techn.* 15,1366-1370. [5] Huber M. S. et al. 2014. 45th Lun. and Planet. Sci. Conf. Abstract #2108.