

Atmospheric entry heating in cosmic dust

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Micrometeorites (MMs) and interplanetary dust particles (IDPs) experience atmospheric entry heating, with the degree of heating depending on their speed, entry angle, density and size [1]. The majority of particles are vaporised, with surviving MMs subclassified based on the level of melting: completely melted, partially melted (scoriaceous, Sc), or unmelted (Un) [2]. During a particle's lifetime in space, solar wind (SW) noble gases are implanted into the surface. This includes abundant He, which is subsequently lost to variable degrees during atmospheric entry depending on peak temperature (T_{max}). This means He can be used as a thermometer for T_{max} of heating during atmospheric entry by determining a release curve over a defined temperature range [3,4].

Thirty-four MMs from the South Pole Water Well [5] were measured for their noble gases to estimate their T_{max} . The T_{max} were compared to MM textures derived from X-ray microtomographic and SEM images to understand the link between temperature and texture. Helium release curves were obtained for 24 MMs, and He and Ne were measured for all samples at a laser temperature of 1650 °C.

Helium release curves indicate T_{max} of 800-1600 °C for MMs. A larger temperature range is observed for coarse-grained UnMMs compared to fine-grained UnMMs, which may reflect different responses to heating based on precursor mineralogy. Un/ScMMs with higher than expected temperatures for their classifications indicate thermal gradients during heating. Neon isotopes are dominated by fractionated SW. A few MMs have ²¹Ne excesses, from which cosmic ray exposure ages and orbital origins are being calculated [7]. Additionally, a peak in ³He/⁴He ratios is observed at $2.4\text{-}2.5 \times 10^{-4}$, which may arise from the balance of SW implantation and erosion. We plan to expand this study with measurements of IDPs.

[1] Love and Brownlee (1991) *Icarus* 89:26-43. [2] Genge et al. (2008) *Meteorit. Planet. Sci.* 43:497-515. [3] Nier and Schlutter (1993) *Meteoritics* 28:675-681. [4] Joswiak et al. (2007) *Proc. 'Dust in Planetary Systems'* (ESA SP-643). p.141-144. [5] Taylor, S. et al. (1998) *Nature* 392:899-903. [6] Kohout et al. (2014) *Meteorit. Planet. Sci.* 49:1157-1170. [7] Feige et al. (2024) *Philos. T. R. Soc. A.* 382: 20230197.