A NEW VIEW ON INTERSTELLAR DUST – HIGH FIDELITY STUDIES OF INTERSTELLAR DUST ANALOGUE TRACKS IN STARDUST FLIGHT SPARE AEROGEL

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Introduction: In 2000 and 2002 the Stardust Mission exposed aerogel collector panels for a total of about 200 days to the stream of interstellar grains sweeping through the solar system [1]. The material was brought back to Earth in 2006. The goal of this work is the laboratory calibration of the collection process by shooting high speed [5 - 30km/s] interstellar dust (ISD) analogues onto Stardust aerogel flight spares. This enables an investigation into both the morphology of impact tracks as well as any structural and chemical modification of projectile and collector material. First results indicate a different ISD flux than previously assumed for the Stardust collection period [8].

Method: Laboratory analogue shots on Stardust collectors requires complete control of particle size and speed over a wide dynamic range. A complete range of speeds up to 30 km/sec can only be achieved by a Van de Graaff accelerator such as operated at the MPI für Kernphysik (Heidelberg) [2]. Using a recently improved version of the Particle Selection Unit (PSU), individual shots with defined speed and particle size are performed. Thus the experiments provide clear advantages over shots with a light gas gun and can be carried out using a variety of cosmochemically relevant materials (silicates, sulfides, metals, oxides, carbides). For use in the electrostatic accelerator, these mineral grains [~ 0.1 – 2µm in size] are coated by a thin conductive layer of either platinum [3] or polypyrrole [4].

Results: A major campaign started in spring 2010 with the goal to characterize tracks of interstellar grains with respect to the projectile speed, size, and density. Three different materials (orthopyroxene, iron, polystyrene) were therefore shot within several narrow speed and size windows (e.g. 14 - 16 km/s, 0.37 – 0.43µm). For each set of parameters, about 50 particles were collected. Aerogel properties, generally controlled by density, can be quite variable. In order to remove systematic uncertainties due to differences in aerogel batch, a single aerogel tile for each set of shots was used. To distinguish between the tracks, the zenith angle (45°) was held constant and the tile rotated through different azimuth angles in increments of 30°. The different populations are thus readily distinguished within a single aerogel tile.

First the tiles have been surveyed in an optical microscope to identify impacts. Then track diameters and depths were measured optically at high magnification using an encoded stage with 0.5µm precision. Subsequently tracks in picokeystones[5] were extracted and analyzed with Scanning Transmission X-ray Microscopy (STXM) at the Advanced Light Source in Berkeley, CA.

Fig. 1 shows the diameter of tracks at the aerogel surface as a function of particle size and speed for orthopyroxene and polystyrene. Theory predicted a track diameter dependence of $v^{1/2}$ [6]. The experiments, however, imply a much steeper curve with an exponent of about 1 or slightly higher. Therefore, the tracks are significantly larger than previously expected for high capture speeds.

First STXM results show a bulbous track shape at 15 km/s similar to type A Stardust tracks (Fig. 2) with a terminal particle. For the first time it could be shown experimentally that cores of sub-micron minerals survive aerogel capture at speeds well above 10km/s.

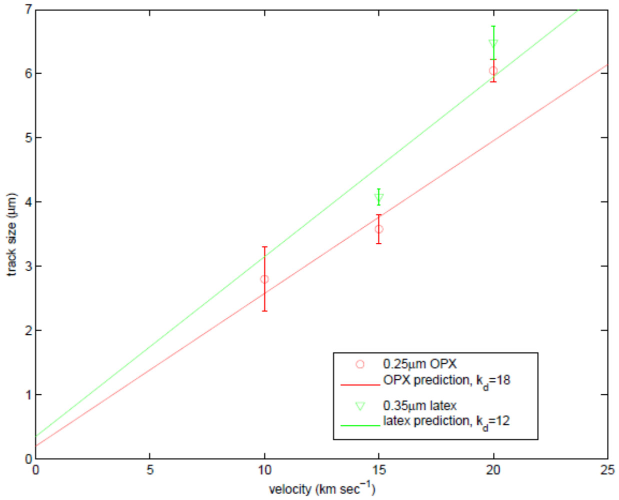

Figure 1 *Track diameter as a function of projectile velocity. The fitting function used here is*
$D_{track} = D_{particle} (K_d (v / 15 \text{ km/sec}) + 1)$
Note that this is a preliminary result of work in progress which will be updated on the conference.

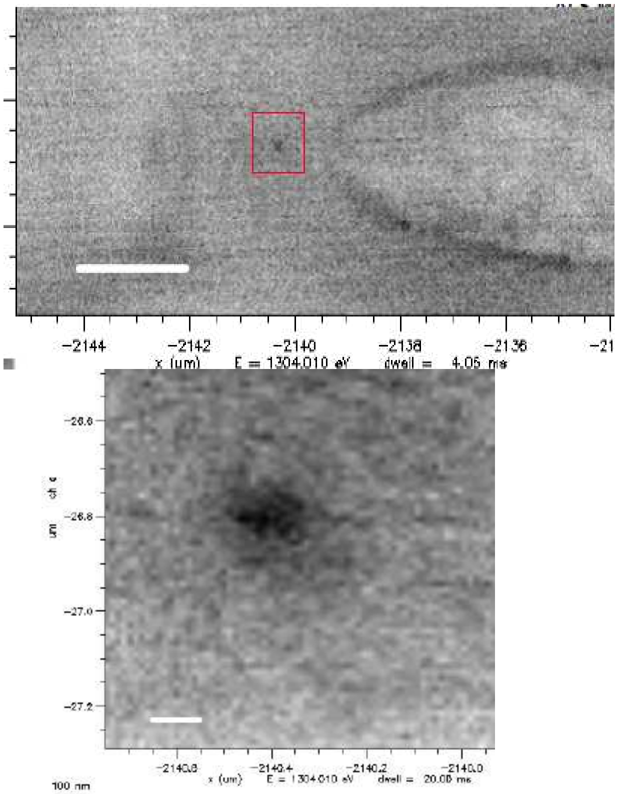

Figure 2 *STXM Image of track and terminal particle. Impactor size: 0.33µm, capture speed: 15 km/s.*

Discussion: STXM Mg-K near edge absorption fine structure spectroscopy of 1/3 micron ortho-pyroxene shots identifies that terminal particles can survive. Its low Mg content points at a heavy mixing with aerogel. This is consistant with its almost spherical shape and small size that indicates partial melting. Therefore, surviving particles in the stardust collection which are not heavily mixed with aerogel or aerogel glass either indicate a larger initial grain, or a lower impact velocity.

Tracks of interstellar grain analogues are easily detectable in the applied speed range and thus should be also found in the real collector aerogel. However, tracks of the morphology found in the lab are rare in the original aerogel Stardust tiles which have been exposed to interstellar dust [7] and much less abundant than implied by previous modelling of the interstellar dust flux [8]. Improved modelling carried out for this work might be able to explain this discrepancy. The new results point to a more effective deflection of small ISD's by solar wind magnetic field interaction and radiation pressure. Therefore, fluxes of such particles in the inner solar system probably are smaller than previously assumed. In addition, the relative collection speeds might have been lower.

Starting in April 2011 the experiments will be repeated with the same material but with a focus on speeds below 10 km/s. Furthermore, new materials (spinel/pyrrhotite) will be shot. This time the projectiles will also be shot onto Stardust and Genesis collector foils which will allow a one-to-one cross-calibration between tracks found in aerogel and foil-craters [9].

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