Hydrocode modeling of micrometer scale impacts into Al foil: implications for analyses of Stardust ISPE craters

Conference or Workshop Item

HYDROCODE MODELLING OF MICROMETRE SCALE IMPACTS INTO Al FOIL: IMPLICATIONS FOR ANALYSES OF *STARDUST* ISPE CRATERS.

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Introduction: This work provides a validated hydrocode model to help interpret impact velocity and angle (and thus impactor origin) from non-destructive measurements of the dimensions of craters found on the *Stardust* interstellar collector foil. We have used a modified Cowper-Symonds [1] strength model for Al-1100 within AUTODYN, incorporating strain rate (and strain) hardening and pressure dependent melting [2] Our model has now been validated against experimental data for silica and sodalime glass (slg) projectiles fired onto *Stardust* flight spare foil at velocities of 6.1 km s^{-1} [3, 4] and sub-micron iron particles accelerated in a Van de Graaff (VdG) accelerator [5, 6] at velocities up to 27 km s^{-1}. Results from recent experiments using the VdG accelerator in Heidelberg [7] are also being used to extend the validation.

VdG analogue foil shots. Two campaigns used *Stardust* flight spare foil as targets: ***March 2010*****:** Platinum coated orthopyroxene (OPX) with particle diameter approx. 0.4 µm, accelerated in four runs to 6 (twice), 15 and 20 km s^{-1}. Data from these four foils are described in [2]. ***Apr.-May 2011*****: (i)** Polypyrrole coated olivine projectiles of ~0.25 µm diameter, accelerated to: 3, 6, 10, 15, 20, 70 km s^{-1}. **(ii)** Polypyrrole coated polystyrene (~0.4 µm diameter) accelerated to 3, 6, 10 km s^{-1}. **(iii)** Pt coated OPX (~0.25 & ~0.4 µm diameter): accelerated to 3, 6, 10, 15 km s^{-1}.

Results: The hydrocode model reproduces the experimentally derived crater dimensions to within 10% for the majority of the data and, at worst, to within 25% for the highest speed and smallest projectile. This validation covers a range of projectile sizes from 150 nm - 4 µm, impact velocity 6 – 27 km s^{-1} and projectile density from 2.4 – 7.8 g cm^{-3}.

Discussion: Recent analyses [8, 9] of two sub-µm diameter craters on the *Stardust* interstellar collector foil show they were almost certainly made by secondary ejecta from the Zn- and Ce-bearing solar panel cover glass. Secondary glass particles are likely to have been ejected with a wide range of speeds, up to a few 10s of km s^{-1}, to impact on the collector at oblique angles [10]. 3-D numerical modelling of glass impactors is ongoing to determine the effect that solid impactor shape, impact angle and velocity may have on crater shape and if any measureable crater metric could be used to help determine an impactor's trajectory and velocity.

References: [1] Cowper G. R & Symonds P. S. (1957). *Tech. Report #28*, Brown University. [2] Price M. C. et al. (2011), *MAPS (sub.).* [3] Price M.C. et al., (2010). *MAPS* 45, 1409. [4] Kearsley A. T. et al., (2006). *MAPS* 41, 167. [5] Davidson R. F. & Walsh M. L. (1995). *Proc. of the SCCM.* [6] Stradling G. L, et al., (1992). *Proc. of the HVIS.* [7] Mocker A. et al., (2011). *Rev. of Sci. Instruments (sub.).* [8] Stroud et al. (2011). *These proceedings.* [9] Floss et al., (2011). *These proceedings.* [10] Westphal A. et al., (2008). *LPSC XXXIX #1855.*