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Momentum transfer measurement of laboratory hypervelocity impact experiments on asteroid-like materials as a function of target porosity and projectile shape

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ABSTRACT

Currently, more than 8 000 Near-Earth-Objects (NEOs) are known in our solar system that can potentially hit the earth and can cause serious damage. A kinetic impactor, i.e. the impact of a mass at high speed, may possibly avert a collision. This scenario is investigated in this work by basic laboratory experiments.

Upon impact of an impactor, momentum transfer takes place. This can be used to significantly change the path of the celestial body. The magnitude of the momentum transfer depends on several factors (i.e. target and projectile material, projectile velocity, projectile shape). The transferred momentum to the target after an impact exceeds the initial momentum of the projectile. This effect is caused by ejection of fragments in the direction opposite to the flight direction of the projectile. The momentum transfer is generally expressed by a dimensionless quantity called momentum multiplication factor or simply β, which is defined as the ratio of the target momentum after the impact and the momentum of the projectile:

$$\beta = \frac{p'_{target}}{p_{projectile}} = \frac{p_{projectile} + p_{ejecta}}{p_{projectile}} = 1 + \frac{p_{ejecta}}{p_{projectile}}$$

At Fraunhofer EMIs two-stage light-gas accelerator impact experiments with a wide velocity range were conducted on materials with different characteristics. Different impact velocities, target porosities and shapes of aluminum projectiles (i.e. sphere, cylinder, disk) were used to investigate the momentum transfer from the projectile to the target. It was shown, that the momentum multiplication factor β decreases as a

function of increasing porosity. It was also shown, that any shape other than spherical generate a higher β.

This paper presents the major results of EMIs laboratory experiments within the EU FP7 founded NEOShield project.