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Numerical study of the asteroid deflection efficiency of the kinetic impactor approach in the NEOShield project.

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ABSTRACT

Due to their impact potential, Near-Earth Objects present a scientifically well-founded threat to our civilization. Several ideas have been proposed to deflect a small body on a collision route to the Earth. Here we focus on the kinetic impactor method. This technique consists of impacting the small body with a projectile (spacecraft) and using the transfer of momentum provided by the impact and the resulting ejecta to deviate the object. The momentum transferred in such an impact is usually characterized by a factor β (≥ 1) known as the momentum multiplication factor:

$$\beta = 1 + p_{ej}/(M_p v_p)$$

where p_{ej} is the momentum of the ejecta, M_p and v_p are the mass and velocity of the impactor. β is a crucial quantity that determines the deflection efficiency of the kinetic impactor approach. Its value depends on the target characteristics (material properties, internal structure, surface structure, size) and also on the velocity of the impactor. In addition to impact experiments and scaling laws, numerical simulations of impacts are needed to determine β under various conditions at asteroid scales.
In the framework of the European NEOShield project, we are investigating the β values as a function of impact conditions and target material properties. This study is performed using a 3D SPH impact code including a model for porous material and recently improved strength models (Benz and Asphaug 1995, Computer Physics Communications 87; Jutzi et al. 2008, Icarus 198; Jutzi et al, in prep).

In a preliminary study, the effect of impacts of spherical 400 kg projectiles (density ρ = 1 g/cm^3) with velocities between 1-10 km/s have been investigated using various target structures (e.g. monolithic microporous targets with macroscopic cracks etc.). Figure 1 shows an example of a target before and after a 10 km/s impact. Preliminary results show a good agreement with laboratory experiments (Housen and Holsapple, LPSC 2012).

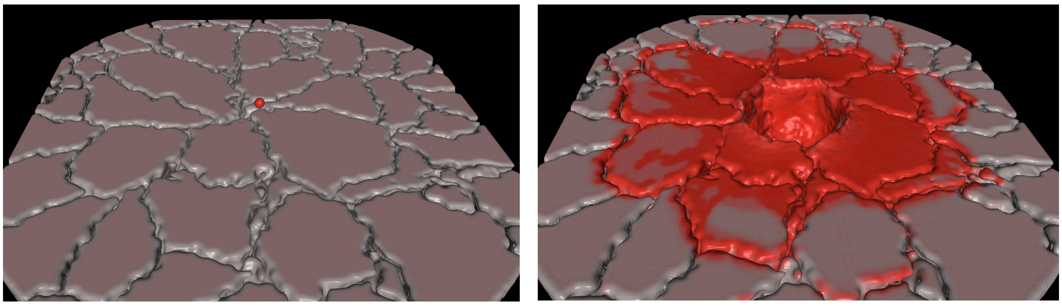

Figure 1: Example of initial target (left) and result of the impact (right). The initial target contains microscopic voids and macroscopic cracks. On the right, red color indicates damage and one can see the crater produced by the impact.

To compute the momentum multiplication factor β, we take into account that only material with v_{eject} > v_{esc} escapes the body and contributes to the momentum transfer. We then calculate β using the velocity vectors at infinity, $\mathbf{v}_{infinity}$, which are determined by computing the hyperbolic orbits of the ejected particles (Figure 2). This procedure is similar to the approach by Housen and Holsapple, Icarus 221, 2012.

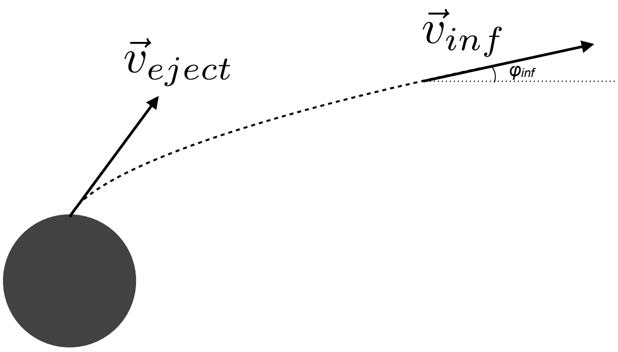

Figure 2: Velocity vector at ejection, hyperbolic orbit (dotted line) and velocity vector at infinity (not to scale).

We will present new results of this study where we focus on the dependence of β on the impact velocity and on the comparison with scaling laws (Housen and Holsapple, Icarus, 221, 2012)

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