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EFFECTS OF IMPACT DEFLECTION ON HAZARDOUS ASTEROIDS: THE ROLE OF ASTEROID INTERIOR STRUCTURE

Yun Zhang[(1)], Yan Liu[(2)], Hexi Baoyin[(3)], and Junfeng Li[(4)]
[(1)] *Affiliation: School of Aerospace Engineering, Tsinghua University. postal address: Mengminwei Science and Tech Building Room N904, Tsinghua University, 100084, Beijing, China. Phone: 8615120004073.*
[(2)] *Affiliation: School of Aerospace Engineering, Tsinghua University. postal address: Mengminwei Science and Tech Building Room N909, Tsinghua University, 100084, Beijing, China. Phone: 8601062789122.*
[(3)] *Affiliation: School of Aerospace Engineering, Tsinghua University. postal address: Mengminwei Science and Tech Building Room N903, Tsinghua University, 100084, Beijing, China. Phone: 8601062773402.*
[(4)] *Affiliation: School of Aerospace Engineering, Tsinghua University. postal address: Mengminwei Science and Tech Building Room N905, Tsinghua University, 100084, Beijing, China. Phone: 8601062797719.*

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ABSTRACT

The kinetic impact deflection, which is a relatively simple and mature mitigation technique for asteroids defense, would result in a number of unexpected hazardous fragments. For this reason, understanding the outcome of impacts is fundamental to assess the effects of the mitigation technique. Previous studies indicate that the internal structure of asteroid has significant influence on impact process and subsequent collisional evolution. The rubble-pile targets respond to an impact attempt quite differently than monolithic targets. In this paper, we explore numerically the aftereffects of kinetic impact mitigation on both rubble-pile and monolithic asteroids of 1 km in size.
The process of high-velocity impact of a small artificial projectile on an asteroid target is investigated with the material point method (MPM). As a meshfree particle method, MPM is very suitable for solving high-velocity impact problems owing to its prominent advantages of dealing with fracture, fragmentation and moving material interface over the traditional mesh-based methods. In order to evaluate the impact threat of the resulting fragments pose to the Earth, the position of mass center of

impact outcomes is transferred to an circumsolar orbit of hazardous asteroid. An *N*-body gravitational code is developed to propagate the motion of these fragments in the solar system until the predetermined date of impact. The hazard assessment is implemented by analyzing the minimum orbit intersection distance between the fragments and the Earth.

In the simulations, impact speeds range from 3 to 10 km/s, including sub- and super-catastrophic impact conditions. The results show that the largest remnants from rubble-pile asteroids are always smaller than those from monolithic ones at the same impact speed. Meanwhile, for rubble-pile asteroids, the ejected fragments have a wider distribution than for monolithic asteroids. At lower impact speeds, the increase in dispersion of the resulting fragments will reduce the total mass of hazardous objects (the ones who will impact the Earth). Therefore, the rubble-pile targets do less damage to the Earth after taking a low-energy impact attempt. In contrast, high-energy impacts result in more complex distribution of fragments for both types of targets. In general, the total mass of hazardous from the rubble-pile asteroids is larger in this case. We also find that the damage to the Earth can be minimized when a moderate impact speed is taken, which may be significant for mitigation mission planning.

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