PDC 2017
Tokyo, Japan

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Parameter-space study of kinetic-impactor mission design

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Keywords: mission design, planetary defense, trajectory optimisation, asteroid deflection, kinetic impactor

While almost all potentially hazardous asteroids (PHAs) with a size larger than one kilometre have been discovered, it is well-known that the vast majority of the smaller ones are in fact yet to be found. There is therefore an excellent motivation to consider at once all possible Earth-crossing orbits, and to undertake a systematic study of mitigation missions for the entire parameter space of orbital elements.

It is shown that the whole parameter space can be reduced, without loss of generality, to only three relevant dimensionless parameters: the eccentricity and inclination of the asteroid orbit, and the asteroid true anomaly at impact. Ballistic kinetic-impactor mitigation missions are studied for the entire parameter space, considering critical feasibility constraints such as the launcher performance and the illumination conditions at deflection. Different classes of optimal solutions are found to exist and can be directly linked to asteroid orbital properties. The aim of this work is to help identify an appropriate response to the potential threat of a collision of a near-Earth object with our planet, to provide a preliminary mission design, and to determine in which parts of parameter space difficulties may arise.

The problem is studied in three levels. The first one is an analytical optimisation study which ignores the phasing (*i.e.* the Earth and the asteroid are always assumed to be where they are needed), and with both launch and deflection always located on the line of nodes of the asteroid. The new parametrisation indeed leads to simpler equations, and also enables the study of daytime and nighttime impacts at once (which demand significant changes in the required strategy) since it preserves a symmetry of the impact geometry. These results are then validated with a study of the optimised trajectories which again ignores

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the phasing, and finally with a full optimisation including the phasing. In the end, the analytical results indeed prove to be useful to determine which missions can be performed, and to provide preliminary mission parameters. Such results can moreover be used to highlight and provide more insight into the driving physical, geometrical, and launcher dependencies, while helping with the identification of problematic regions as a function of the launcher performance.