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# DEFLECTION OF ASTEROIDS AND COMETS CONSIDERED AS AN AGGLOMERATED BODY

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## ABSTRACT

Recent observations of asteroids and comets made by several spacecrafts have shown a variety set of shapes and possibly internal structures. After these observations, it is suspected that asteroids can have very different internal structures, which can be schematically classified as: i) monolithic objects with surface craters; ii) objects with large internal fractures; iii) reaccumulated objects formed from pieces of a few hundred *m* to *km* in size (the so-called "rubble piles"); and iv) another set of agglomerated objects formed from smaller pieces of a few *m* or less in size (a "pile of boulders"). Asteroids Toutatis and Itokawa might be examples of the two latest groups. We do not know which proportion of main-belt or Near-Earth asteroids belong to each group, but it seems that all the different types do exist.
Several techniques have been proposed to deflect an asteroid in collision course to the Earth, but little has been discussed about the efficiency of these techniques in the different types of asteroids. Among the proposed techniques, we consider the Kinematic Impactor, the Asteroid Tugboat and the Gravity Tractor. We analyze the application of these deflection techniques onto an asteroid considered as a "pile of boulders".
In order to simulate this scenario we make use of the research techniques developed in the frame of Granular Physics. The granular media are formed by a set of macroscopic objects (named grains) which interact through temporal or permanent contacts. The evolution of a collection of grains has been studied experimentally in the laboratory, and, in the last decades, numerically. The Discrete Element Method

(DEM) simulates the mechanical behavior in a media formed by a set of particles which interact through their contact points and under different interaction forces. DEM techniques are able to simulate the evolution of set of thousands up to million particles in computer clusters. For the simulations we have been using the DEM package known as ESyS-particle. We have implemented the effect of the mutual gravity among the grains in the package. We will present the results of DEM simulations of small asteroids subjected to the different deflection techniques.

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