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NIMASTEP: a software to modelize, study, and analyze the dynamics of various small objects orbiting specific bodies

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Abstract

NIMASTEP is a dedicated numerical software developed by us, which allows one to integrate the osculating motion (using Cartesian coordinates) in a Newtonian approach of an object considered as a point-mass orbiting a homogeneous central body that rotates with a constant rate around its axis of smallest inertia. The code can be applied to objects such as particles, artificial or natural satellites, or space debris. The central body can be either any terrestrial planet of the solar system, any dwarf-planet, or even an asteroid. In addition, very many perturbations can be taken into account, such as the combined third-body attraction of the Sun, the Moon, or the planets, the direct solar radiation pressure (with the central body shadow), the non-homogeneous gravitational field caused by the non-sphericity of the central body, and even some thrust forces. The simulations were performed using different integration algorithms. Two additional tools were integrated in the software package; the indicator of chaos MEGNO and the frequency analysis NAFF. NIMASTEP is designed in a flexible modular style and allows one to (de)select very many options without compromising the performance. It also allows one to easily add other possibilities of use. The code has been validated through several tests such as comparisons with numerical integrations made with other softwares or with semi-analytical and analytical studies.

The various possibilities of NIMASTEP are described and explained and some tests of astrophysical interest are presented. At present, the code is proprietary but it will be released for use by the community in the near future. Information for contacting its authors and (in the near future) for obtaining the software are available on the web site
http://www.fundp.ac.be/en/research/projects/page_view/10278201/

Key words: methods: numerical / gravitation / celestial mechanics / space vehicles

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Orbit modeling is the process of creating mathematical models to simulate motion of a massive body as it moves in orbit around another massive body due to gravity. Other forces such as gravitational attraction from tertiary bodies, air resistance, solar pressure, or thrust from a propulsion system are typically modeled as secondary effects. Directly modeling an orbit can push the limits of machine precision due to the need to model small perturbations to very large orbits. Because of this This thesis concerns the dynamics of nanoparticle impacts on solid surfaces. These impacts occur, for instance, in space, where micro- and nanometeoroids hit surfaces of planets, moons, and spacecraft. The high yields at small impactor size are due to the early escape of energetic atoms from the hot region. In addition, the sputtering yield is shown to depend very much on the spatial initial energy and momentum distributions that the nanoparticle induces in the material in the rst phase of the impact. At the later phases, the ejection of material occurs by several mechanisms. In publication III, the sputtering mechanism in gold is simulated and analysed. The stopping phase of gold cluster impact on gold is studied in more detail in publication IV. NIMASTEP: a software to modelize, study, and analyze the dynamics of various small objects orbiting specic bodies. N. Delsate and A. Compère. NIMASTEP is a dedicated numerical software developed by us, which allows one to integrate the osculating motion (using Cartesian coordinates) in a Newtonian approach of an object considered as a point-mass orbiting a homogeneous central body that rotates with a constant rate around its axis of smallest inertia. The code can be applied to objects such as particles, articial or natural satellites, or space debris. The central body can be either any terrestrial planet of the solar system, any dwarf-planet, or even an asteroid.