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TRANSPORT OF NANOSTRUCTURED MATERIAL IN THE INTERPLANETARY MEDIUM

Abstract

The dynamics of nanoparticles in the interplanetary medium is subject to a large number of complicated effects often negligible for larger objects like spacecrafts but dominant for particles in this particular size range. Many theoretical models have been developed to explain the natural dynamics and transport mechanisms of cosmic dust. Building on this knowledge, we here study the solar radiation pressure on artificial nanostructured spheres, as a first step to assess the possibility of establishing artificial material fluxes between orbiting objects.

We consider here an artificial nanoparticle made of a spherical core covered with a coating. The thickness and material properties of the coating are the key parameters which allow us to tailor the final optical response of the nanoparticle. The radiation force depends on the particle's scattering and absorption cross sections, both contributions being equally important. The cross sections were calculated by means of the Multiple Elastic Scattering of the Multipole Expansions (MESME). This formalism will allow us to extend the study to clusters of particles in the future. The results obtained show that it is possible to engineer the value of the radiation force in a wide range by choosing a proper coating. These results allow to envision artificial material transfer routes within the solar system.

As a proof of concept, we show some dynamical calculations in the idealised case of a nanoparticle subject only to the radiation force and solar gravity. The contribution of the Lorentz force is also of relevance for determining realistic orbits. However its implementation requires of an accurate modelling of the space environment (plasma parameters). For the sake of simplicity we decided to constraint ourselves first to the dynamical problem defined only by the forces mentioned above. We solve the inverse dynamic problem to find the particle coating that allows, in a given time frame, to reach selected targets (the case of Mars and Apophis are shown). In this simple framework, the nanoparticle can be considered as moving in keplerian orbits subject to a decreased gravity regime and the particle coating can thus be conveniently considered as a control on the solar mass. This creates an interesting trajectory design problem that we solve showing the possibility to reach the selected targets starting from an Earth trailing orbit and with no required initial DV in the simplified dynamical case considered.

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