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The Interplanetary Meteoroid Environment for eXploration

R. H. Soja (1), M. Sommer (1), R. Srama (1), E. Grün (1), P. Strub (2), J. Rodmann (3), J. Vaubaillon (4), A. Hornig (1), L. Bausch (5) and J. Herzog (1)
(1) University of Stuttgart, Germany, (soja@irs.uni-stuttgart.de) (2) Max Planck Institute for Solar System Research, Göttingen, Germany (3) University of Göttingen, Germany (4) IMCEE, Paris, France (5) AerospaceResearch.net, Germany

Abstract

The 'Interplanetary Meteoroid Environment for eXploration' (IMEX) project, funded by the European Space Agency (ESA), aims to develop a model of recent cometary trails and meteoroid streams in the inner solar system. The goal is to create a database of dust trails from short-period comets in the inner solar system, which can be used for a variety of impact hazard and scientific purposes. Here we discuss the performance of the model for individual trails and the construction of the full database of streams from $\sim$ 400 short period comets.

1. Meteoroid environment modelling

Defining the impact risk from dust impacts in the inner solar system requires an understanding of both the 'static' interplanetary dust cloud, and the time-variant dust populations caused by meteoroid streams in the vicinity of the orbits of comets and asteroids. The major space agencies (ESA and NASA) have meteoroid engineering models to describe the interplanetary meteoroid background [1, 2]. However, no model exists to assess the risk to spacecraft of meteoroid streams (although the ESA model does include a simple representation of the interstellar dust stream). The IMEX project attempts to address this problem: can we predict the impact of meteoroid streams at any point in space or time? This extends the application of meteoroid stream modelling at the Earth to ask whether we can determine 'meteor showers' that occur at spacecraft locations. Such a model is also highly valuable as a database of meteor showers at all planets and other locations in the solar system, and can be used to investigate the creation and development of individual trails.

2. The IMEX Model

We develop meteoroid streams by explicitly ejecting large numbers of dust grains from $\sim$ 400 short-period comets at a variety of masses. The trajectories of these particles are then integrated, accounting for gravitational perturbations and radiation pressure, for hundreds of years. We utilize the Constellation platform to perform these calculations. This is a distributed computing system, where currently 10 000 users are donating their idle computing time at home and thus generating a virtual supercomputer of 40 000 host PCs connected via the Internet (aerospaceresearch.net). This form of citizen science provides the required computing performance for simulating millions of particles ejected by each of the 400 comets, while developing the relationship between scientists and the general public.

We are testing the model using the meteoroid streams from comets 55P/Tempel-Tuttle and 21P/Giacobini-Zinner, which cause the yearly Leonid and Draconid meteor showers at Earth. Our first results show good agreement between our model and the geometry of recent meteor storms and outbursts.

3. Further steps

We are now working to extend the model to provide a unique set of saved orbital information for meteoroid streams from each of the selected $\sim$ 400 short-period comets. This will allow efficient computation of the locations of stream particles at any point in space and time. The benefits of such a database for scientific purposes and impact hazard assessment will be discussed.

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