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METEOROID STREAM MODELLING USING DISTRIBUTED COMPUTING TO DEFINE THE IMPACT HAZARD TO SPACECRAFT CAUSED BY NATURAL SPACE DEBRIS

Abstract

The Interplanetary Meteoroid Environment for eXploration (IMEX) project, initiated by the European Space Agency (ESA), is concerned with modelling meteoroid streams throughout the inner solar system, to help define the impact hazard to spacecraft and to study the presence of meteor showers at locations away from the Earth. This is important because hypervelocity impacts of micrometeoroids can damage or destroy spacecraft or their subsystems through physical damage or electromagnetic effects. Natural meteoroids can be particularly dangerous because of their high speeds relative to space debris particles of perhaps 20 km/s. Such considerations are particularly important in the context of human exploration of the solar system. Our current model ejects cometary particles from more than 400 comets, but only follows the dynamics of these particles using Kepler orbits with a correction for radiation pressure. Planetary perturbations can distort meteoroid streams and lower their density by removal of particles.

However, this integration process can be computationally intensive. In order to complete all the integrations within a reasonable time frame, we use the Constellation platform. It 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. This form of citizen science provides the required computing performance for simulating millions of particles ejected by each of the 400 comets. In addition, it grows relations between scientists and the general public, by making them actively involved in research and educating them about the scientific background and the need for sustainable space transportation.

This ESA-funded IMEX project is conducted in the Cosmic Dust Group of the Institute of Space Systems (IRS) at the University of Stuttgart, with support of the Constellation Group. The paper describes the physical cometary models and simulation algorithms as well as the risk to spacecraft. The

models do not yet fully allow prediction of the appearance of meteor showers, thus we present here improvements on predictability of shower appearances and behaviour on Earth and other planets. The new section integrates the orbits of each particle to include the gravitational interactions with various planets. We test the model for the meteoroid stream caused by comet 55P/Tempel-Tuttle, which is responsible for the annual Leonids meteor showers.