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AN APPROXIMATION TO A GEOGRAPHICAL AND TEMPORAL DISTRIBUTION OF METEOROID IMPACTS ON EARTH

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We describe a novel method to asses the probability of meteoroid impacts at any point on Earth, at any given time. Its implementation involves the adaptation of well-known image rendering techniques and the coupling with numerical ODEs solvers.

Earth's neighbor is populated by tents of families of asteroids whose members orbit the Sun following complex paths that could lead close-encounters and impacts against the planet surface (Granvick et al., 2016). Tunguska and Chelyabinsk impact events, happened just $\sim 2,400$ km away. We might be tempted to think of the existence of a correlation between such events, even though they are no evidence of a pattern in the occurrence of impacts, becoming nothing more than an interesting coincidence. In this work we aim at theoretically predict the instantaneous geographical distribution of meteoroid impacts on Earth.

For that purpose we develop a novel numerical technique, the "Gravitational Ray Tracing" (GRT), that allows us to compute from a prior distribution of impactors in configuration space, the relative probability of impacts in two points on the surface of any astronomical body at a given time. GRT is inspired by the so-called ray-casting techniques used in computer graphics to render photo realistic images of complex 3D scenes (Goldstein & Nagel, 1971). Our technique applies the same idea of studying the propagation of meteoroids from the Earth's surface back to their original sources, instead of simulating the propagation in the future from those sources. The distribution of already detected bodies in the Solar System asteroid families as provided by surveys is used as a way to asses the probability that a given meteoroid could impact the Earth. To compute the instantaneous probability of impact on any place of the Earth, GRT is endowed with a blue noise sampling algorithm (a Poisson-disk sampling technique) to describe the Earth's surface using a set of well spaced random coordinates and avoiding oversampled surface regions. Finally, GRT is provided with a modified Gragg-Bulirsch-Stoer algorithm (Gragg, 1965) that evolves back time the system of hypothetical impactors from the planet surface towards their original sources. Our preliminary results suggests that a non-trivial pattern of impact probabilities exist at any given time on Earth. Points $60-90°$ from the projected direction of Earth's motion (apex) are more prone to impacts, especially at midnight (AM/PM impact asymmetry). GRT allows us to create instantaneous maps of meteoroids impact probability against the Earth or another Solar System planet at any given time.

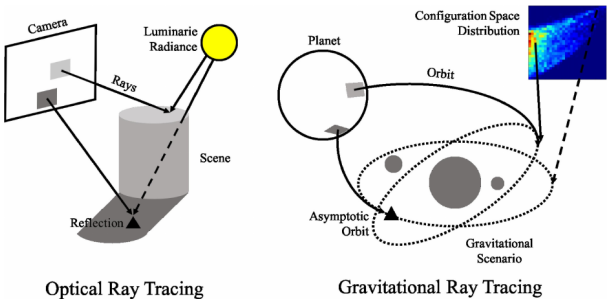

Fig. 1. Schematic representation of the optical and gravitational ray-tracing. The *gravitational scenario* stands for the bodies involved in the force field calculation. The "asymptotic orbit" is the orbit that the test particle reaches when its trajectory is integrated backwards.

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