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Estimating the Impact Probability of a Minor Planet with the Earth

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In recent years, much attention has been given to the problem of computing the probability that an asteroid or comet will impact the Earth. Relatively little attention, however, has been focused on how to compute the probability that a *particular* object will impact the Earth in the relatively near future (the next two hundred years or so). This probability is essentially zero for all currently-known objects, as none of them approach dangerously close to the Earth during this time frame. However, as the recent excitement over Comet Swift-Tuttle has shown, it is important to consider how to estimate this probability for new objects which may come much closer to the Earth.

This paper presents a technique for estimating the impact probability using covariance analysis methods. The components of the algorithm are not new: the computation of impact probabilities for spacecraft has been of interest in the past in the context of planetary quarantine and avoidance of Earth impact of spacecraft carrying nuclear materials. The application of these methods to natural bodies appears to be new.

The algorithm first computes the three-dimensional probability density of the object's position at its closest approach to the Earth, projects this into the plane perpendicular to the relative velocity vector to obtain a marginal probability density, and uses an efficient algorithm to integrate this density over trajectories which would impact the Earth. Differential perturbations over the plane are accounted for by adjusting the locus of the integration.

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