A quantitative approach of the orbital uncertainty propagation through close encounters

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The greatest impediment against collisional predictions of NEOs is their orbital uncertainty and its divergence in time. Repeated close encounters with terrestrial planets generate chaotic motions which make unpredictable the future orbits of these objects. This paper deals with a quantitative analysis of orbital uncertainty propagation through repeated close encounters. We approach this problem analytically and numerically. Using the Opik's formalism on close encounters (motion is divided into two regions: inside and outside of the Hill's sphere of action) and making use of extensive symbolic computations we evaluate the post-encounter difference between two orbits, initially very close. We highlight critical orbits for which the uncertainty propagation takes place faster. In our numerical approach, we evaluate the orbital dispersion in the phase space of orbital elements for various encounter scenarios through a Monte Carlo simulation. A Runge-Kutta-Radau 15^{th}-order integrator is used. We emphasize the progressive degradation of orbital uncertainty from one encounter to another. The reliability of Lyapunov characteristic exponent and of the orbital D-criterion in evaluating the frequency of close encounters is discussed.