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Comparison of various orbital similarity functions

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Abstract

Orbital similarity functions are used for identification of meteoroid streams, asteroid families and common descent of asteroids, meteoroids and comets. Recently, Vokrouhlický and Nesvorný [1] used them in search of close orbital pairs of asteroids that could have common origin. In their work Vokrouhlický and Nesvor used slightly modified version of orbital distance function introduced by Zappala. We decided to follow their work, but applying few different metrics.

We considered five different orbital similarity functions. All of them represent distance between asteroid orbits in five-dimensional space of osculating orbital elements, namely: a, e, i, ω, Ω. First metrics, hereafter referred to as D_{SH}, was introduced by Southworth and Hawkins who were looking for a criterion for meteoroid stream membership. Two following functions, D_{DR} introduced by Drummond and D_H suggested by Jopek [2], base on this first metrics, the latter introducing only minor changes. In 2007 Jopek et al. [3] proposed new distance function involving heliocentric vectorial elements of meteoroid orbits, D_{VEC}. The fifth metrics, D_{VN}, was introduced by Zappala, but in our computations we used its modified version with the set of weightening parameters used by Vokrouhlický and Nesvorný.

We compared results of all five metrics for database of asteroid elements `astorb.dat`, calculated by Ted Bowell, see website [4]. We used the version of catalogue downloaded on 24th April 2009. All orbits were sorted according to their semimajor axes. Each orbital similarity function was calculated separately. We calculated the D values for the orbits differing by no more than $0.001AU$ in semimajor axis. Sets of 600 closest pairs chosen by each metrics were compared.

We decided to plot orbital inclination versus eccentricity for 600 closest pairs selected by all considered metrics. Example plot is included in this abstract. For D_{DR} we can see a concentration of asteroids with small inclinations and eccentricity between 0.12 and 0.23. Such clusterind can be also found on similar plots for D_{SH}, D_H and D_{VEC}, but in the region of eccentricities smaller than 0.1. The distribution of orbital elements for pairs chosen by D_{VN} seems to be more even. This test showed that various orbital difference functions have different sensivity to orbital elements.

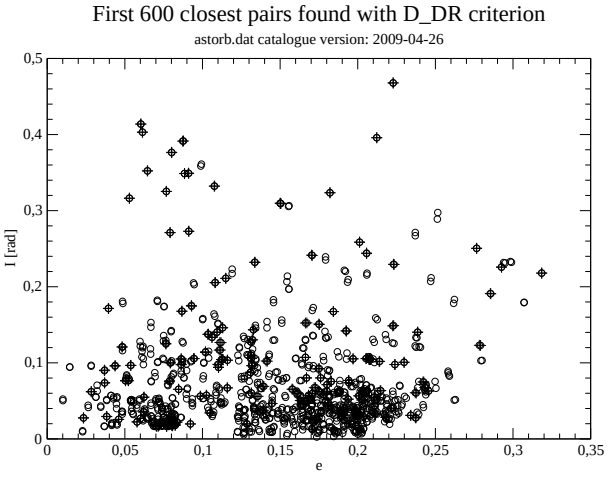

Figure 1: Circles mark asteroids in pairs found using the D-criterion introduced by Drummond, crosses idicate pairs identified with all the metrics that were tested. Red background idicates orbital elements of all asteriods in `astorb.dat` catalogue.

This work will be continued with numerical simulation of dynamical evolution of orbital distance function for artificial pairs in time interval of few housands years. Initial orbital elements of asteroids in the artificial pairs that should be used for computation will be chosen in such matter that they would be regarded as close pairs by the orbital similarity functions used in this work.

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