Probability of coincidental clustering among the orbits of small bodies

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Introduction

The major tool for finding clusters among small bodies of the Solar System has been orbit similarity, quantified by a function called D-criterion. Finding a very similar orbits among the asteroids, comets or meteoroids always rise a question — whether such similarity is only a chance coincidence? To give answer we need an adequate value of the orbital similarity threshold (a key parameter of any cluster analysis) corresponding to the value of the probability of a chance similarity between two or more orbits.

Reliability of orbital grouping is quite old problem, first time engaged in [5] and [3]. However, due to limitation of the computing power at that time it was rather problematic to accomplish an extensive reliability test of detected groups. So no values of the probabilities were assigned to the identified pairs or groups of meteor orbits. Afterwards the problem was elaborated more extensively in [1, 2] or more recently in [4].

Our work

In this study we made use of our earlier experiences [1] and the approach described in [4]. Both methods are based heavily on the artificial orbital samples. We have shown that both methods give consistent results but the method proposed in [4] needs more computing power.

Sets of the synthetic meteoroid's or asteroid's orbits one can generate in different ways:

- using different statistical properties of the orbital elements generated randomly,
- by taking (or not) into account correlation between some orbital elements.

We have investigated how such different methods impact assessment of the probability of pairing or grouping among the orbits?

Probability of random grouping depends on several other factors like the size of the orbital sample searched for clusters or the size of the identified group. It is different for groups of 2, 3 ... members. Of course it depends on the cluster analysis method applied.

We tested the impact of some of these factors. For a given size of the orbital sample we have assessed probability of random grouping for several groups of different sizes. On the other hand, for a given size of the identified group we have found how these probabilities vary with the size of the orbital samples.

Finally, keeping fixed size of the orbital sample and the size of the group, we have shown that the probability of random grouping can be significantly different for the orbital samples obtained by different observation techniques.

This result is important, it means that contrary to quite common practice we should rather not use the values of the orbital similarity thresholds applied by someone in earlier study e.g. for searching for streams among video orbits. For given orbital sample and the cluster analysis method one should find the proper values of the orbital similarity threshold for each group of 2,3,4, ... members, severally.

References

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