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Recent Investigations on the Accuracy of Asteroid Ephemerides

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Abstract

The orbit uncertainty of asteroid presents a particular interest for Near-Earth asteroids in order to estimate their close approach from Earth and eventually their risk of collision. Using ASTORB [1] and MPCORB [2] databases, we analyse the different uncertainty parameters (CEU, U). Relations between the uncertainty parameter and the characteristics of the asteroid (orbital arc, absolute magnitude, ...) are highlighted. A review of the different measurements are also compilated and the impact of these measures on the accuracy of the orbit is also estimated.

1. Introduction

Since February 2010, the number of discovered asteroids exceeds 500 000. The large number of asteroids allows a statistical analysis particularly about their orbital uncertainty. In this context, we deal with two databases of asteroids, ASTORB [1] and MPCORB [2] and we study the parameters related to the orbital uncertainty.

2. State of the Art

The ASTORB and MPCORB databases provide information about name, orbital elements, magnitude and observations of asteroids. They also give their orbital uncertainty: U parameter is an integer value between 0 (good orbit) and 9 (bad orbit) provided by MPCORB. Current Ephemeris Uncertainty (CEU parameter) given by ASTORB is the orbital uncertainty in the sky-plane in arcsec. ASTORB also provides the rate of change of CEU and the future peak of CEU.
There is a positive correlation between these parameters however some asteroids appear to have a good orbit in a database and a bad one in an other and conversely. By considering these specific cases and the general one, the CEU appears to be the best parameter to estimate the orbital uncertainty as it is quickly computable, precise and providing a physical value (an angle).

3. Relations between orbital and uncertainty parameters

The CEU can be related to the orbital arc. The decrease of the CEU seems obviously related to the increase of the orbital arc. In this context, we have tried to find a relation between these two parameters (Fig 1). In this figure, four groups of asteroids can be identified using the length of their orbital arc:

- arc < 10 days
- 10 days $\leq$ arc < 250 days
- 250 days $\leq$ arc < 8000 days
- 8000 days $\leq$ arc

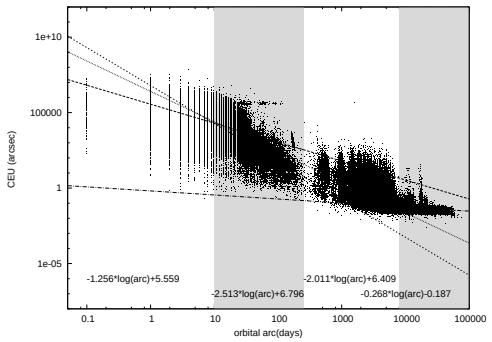

Figure 1: Relation between the length of the orbital arc and CEU for all asteroids, and slope for the 4 classes identified (see text)

For each group, linear regression can be computed and we have a empirical relation between the value of

CEU and the length of orbital arc:

$$\log(CEU) = a\log(arc) + b \quad (1)$$

where a and b are given in the figure for each groups. If the orbital arc is smaller than 10 days, the CEU is very large and does not much improve when the length of arc becomes greater. Between 10 and 250 days, the CEU is cleary improved if the length of arc increases. For asteroids with an orbital arc between 250 and 8 000 days, the CEU is smaller than 100 arcsec and is still much improved when the length of arc becomes greater. If the orbital arc is greater than 8 000 days, then the CEU is not much improved and reaches its typical minimum value (about 0.1-0.2 arcsec).

4. Astrometric measurements

The orbit of an asteroid can be determined using different measurements such as astrometric observations (CCD, photographic, micrometric), radar measurements (ranging, doppler), space observations, etc... For these measurements, we present the frequency, the accuracy and the time span.
We study the specific case of asteroid Apophis and analyse the impact of these measurements (current and future) on its orbit. In this context, we use simulations and deal with the problem of the uncertainty in both space and target plane. We have quantified the impact of radar measurement and future observations from Gaia mission on the uncertainty of Apophis orbit. The confidence region in the target plane will be reduced by these measurements allowing the refinement of the orbit and the probablility of collision in the future.

5. Summary and Conclusions

This study presents recent investigations on the accuracy of asteroid ephemerides. An analysis of the different parameters related to uncertainty is presented and relations between CEU and orbital parameters are highlighted. We also provide a compilation of astrometric measurements with their accuracy, time span and frequency. Finally, we deal with the specific case of Apophis in order to quantify the impact of these measurements on the orbit uncertainty and the probability of collision.

Acknowledgements

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References

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[2] Minor Planet Center , MPCORB database, `http://minorplanetcenter.net/iau/MPCORB.html`, April 2011