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Solution stabilization algorithms for the estimation of small bodies orbital parameters

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Sometimes there is not enough information for the correct improvement of the orbits of the Solar system small bodies. As a rule it is caused by lack of observations or by too short arc of orbit covered by observations. Therefore one can obtain only a set X of acceptable solutions satisfying the given observations with the adequate accuracy.

In this work some stabilization algorithms for solution of such problems have been considered. Algorithms have been constructed on the basis of a linear least squares method using additional a priori information about the solution. This additional information is given as restrictions on the solution or its components [1].

This approach has been developed for the estimation of the initial orbital parameters of asteroids moving in the vicinity of a resonance with one of large planets. A condition of keeping the smallness of the resonance bound $\alpha = k_1 n_a - k_2 n_p$, where n_a is mean daily motion of an asteroid, n_p is mean daily motion of planet, k_1, k_2 are integer numbers, is taken as the restriction on the solution. Based on this condition two algorithms have been constructed.

In the first algorithm additional observations are simulated. Then this observations are used together with real ones in orbital parameters improvement by least squares method. The simulated observations are constructed on the test orbit taken from the region of possible motion of the object. This orbit satisfies the condition $|\alpha| \leq \rho$, where $\rho > 0$ is a given small quantity. The technique of construction of possible motion regions is described in [2].

In the second algorithm the least square problem with linear restrictions in the form of the inequalities for the major axis of asteroid is solved. These restricting inequalities correspond to a resonance of the object under consideration.

For investigation of the efficiency of such approach the numerical experiment for the example of some asteroids moving in the vicinity of 3/1 resonance with Jupiter and having close encounters with inner planets has been made. Equations of motion have been integrated numerically by the Everhart method [3]. Perturbations from all large planets and the Moon which coordinates were taken from ephemerides DE200/LE200 have been taken into account. Equations of motion in rectangular coordinates have been used in the first algorithm. In the second one Keplerian elements have been used.

To avoid additional computation errors a singular decomposition algorithm for the matrix of the conditional equations have been used in the least squares problem solution. It is well known that this algorithm is stable to the errors of initial data.

Numerical experiments have shown that both methods allow to obtain acceptable solutions. However the use of the first algorithm for finding a test orbit that satisfies condition $|\alpha| \leq \rho$, where $\rho > 0$ is a given small quantity, is not possible for all asteroids.

References

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