

ON THE IMPROVEMENT OF THE SYSTEM OF FUNDAMENTAL CATALOGUES BASED ON ASTEROID OBSERVATIONS

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ABSTRACT. The question concerning the influence of the consideration of asteroid mutual perturbations on the calculated positions of 20 selected minor planets as well as on the fundamental catalogues systematic corrections is discussed.

1. Materials and methods

The equation of motions of 20 selected minor planets (SMP) were integrated within 1948–2000 interval. The epoch of the initial elements was 1980, December 27 (JD 2444600.5). The list of perturbing asteroids included Ceres (1), Pallas (2), Juno (3) and Vesta(4); the perturbations caused by major planets were excluded.

To estimate the mutual perturbations of SMP the geocentric RA and Dec of a minor planet derived on the bases of disturbed and non-disturbed orbits were compared every 50 days.

It is important to estimate the methodical error of the calculated positions of minor planets caused by the neglect of their mutual perturbation (mathematical model error). It can be done by comparing the most probable disturbed and non-disturbed orbits derived on the basis of the same set of observations. For minor planets (1)–(4), (39), and (40) with significant perturbing terms the estimates were found using the fictitious observations while the perturbation of corresponding geocentric coordinates served as differences O–C. The residuals after improvement of the orbital elements in the case of this model were interpreted as a first approximation of the method error to be found [1].

The influence of mutual perturbations of minor planets on the estimates of systematic corrections to the fundamental catalogue was studied using fictitious observations of Ceres, Pallas, Juno and Vesta [2]. The unknown corrections to the equinox ΔA , the equator $\Delta \delta_0$, and 6 orbital elements for every minor planet as well as to the 5 Earth orbital elements were included in the equations of condition. The equations were solved for every particular planet and for the four planets in common. The derived estimates of ΔA and $\Delta \delta_0$ present the errors of the corresponding catalogue corrections due to neglected perturbations.

At the last stage the residuals after combined solving were averaged for $3^h \times 15'$ equatorial areas.

2. Results and discussion

Limited values of perturbations in geocentric α and δ of SMP for the period mentioned above are given in the Table 1, when the combined influence of four massive asteroids was taken into account.

The maximum values of methodical errors of calculated geocentric positions within the whole interval reached $\Delta\alpha_m = \pm 0''.86$, $\Delta\delta_m = +0''.39$ for Vesta, $\Delta\alpha_m = -0''.33$, $\Delta\delta_m = -0''.10$ for Pallas and $\Delta\alpha_m = +0''.23$, $\Delta\delta_m = +0''.15$ for Harmonia. For other planets they are smaller. For some cases the error exceeds 0''.1 near the epoch of elements. These errors are of systematical character and should be taken into account if high precision reduction of observations of SMP is carried out.

The analysis of solutions for catalogue zero-points corrections showed that the consideration of asteroid perturbations did not practically influence ΔA and $\Delta\delta_o$, especially in the combined solution. At the same time the neglected mutual perturbations may give rise to estimates of regional catalogue corrections up to 0''.05–0''.07 which are of the same order as the systematic errors of the fundamental catalogue. That is why mutual perturbations of asteroids should be taken into account while systematic errors of fundamental catalogues are studied by ground-based and space-based observations of minor planets.

Table 1. The maximum values of perturbations of SMP caused by the first four asteroids within the 1948–2000 interval.

Planet	$\Delta\alpha_m$	$\Delta\delta_m$	Planet	$\Delta\alpha_m$	$\Delta\delta_m$
Ceres	-0''.29	+0''.09	Phocaea	+0''.21	+0''.06
Pallas	-0.72	-0.14	Gallia	+0.04	+0.01
Juno	+0.35	+0.07	Industria	-0.23	+0.06
Vesta	+2.00	+0.40	Hansa	-0.14	+0.03
Hebe	+0.07	-0.02	Herculine	-0.41	+0.15
Iris	+0.35	+0.10	Cheruskia	+0.17	+0.16
Parthenope	-0.28	-0.06	Olimpia	+0.32	+0.06
Melpomene	+0.46	-0.13	Mireille	+0.68	+0.09
Laetitia	-0.65	-0.12	Interamnia	+0.64	+0.20
Harmonia	+1.14	-0.33	Ivonne	-0.56	-0.10

References

1. Fedij, P.M. (1988) 'On the precision of the ephemerides of selected minor planets derived by not taking into account their mutual perturbations', *Kinematika i fizika neb. tel*, 4, 6, p.86–88.
2. Fedij, P.M. (1989) 'The influence of mutual perturbations of minor planets on systematic corrections of star catalogues', *Kinematika i fizika neb. tel*, 5, 1, p.94–96.