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Using positional observations of minor planets for improving the orientation of star catalogue

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Discovery of new groups of minor planets (NEAs, Koiper belt, binary asteroids) attracts attention of observers mainly to these objects. Bright minor planets of the main belt have long observational history and therefore we know their orbital parameters rather precisely. That is why these minor planets are not considered now as very interesting objects for positional observations. But experience shows that this kind of observations can be used succesfully for improving orientation parameters of star catalogues with respect to dynamical reference system. However, for their advantageous use these observations should be homogeneous, cover sufficiently long time interval and be reduced to one reference star catalogue. One can note the following two groups of observations: 1) photographic observations of 15 selected minor planets made during 1950–2000 [1] with accuracy on the order of $0.25'' - 0.30''$ and 2) Hipparcos observations of 48 bright minor planets made during 3.3 years, referred to ICRF and having accuracy of about $0.015''$. Combined processing of these two groups of observations made it possible to obtain orientation of ICRF with respect to DE200 [2]. The accuracy of this result was proved to be comparable with those of LLR and VLBI measurements.

Since 1997 Stone [3] realizes a new program of observations of the first 2000 numbered minor planets. The CCD observations were taken with Flagstaff Astrometric Scanning Transit Telescope (FASTT) and were reduced differentially to ICRF equatorial positions using reference stars taken from the ACT star catalogue.

In present paper all these series of observations have been used for improving the orientation of Hipparcos star catalogue. For this purpose about 500 minor planets having sufficiently large number of observations (> 70) were selected from those observed by Stone. For the observations of these planets the best accuracy value is equal to $0.050''$, the mean accuracy is equal to $0.09'' - 0.10''$. Such an accuracy is several times better than the mean accuracy of usual positional observations of minor planets.

Then, preliminary simulation of solution was done with the aim to reveal the most suitable minor planets for solving our task. This simulation confirms the known result, i.e. all other things being equal the nearer object is to the Earth the better results can be obtained using its observations for determination of orientation parameters. Then, it was shown that for the best determination of velocity changes of orientation parameters the semi-major axes within the limits $2.0 - 2.5$ a.u. should be chosen.

The following model of motion and processing observations was used. Positions of minor planets were determined with accounting for the perturbations from nine major planets in correspondence with DE403. Besides, the perturbations from 300 minor planets were taken into account. Masses of these 300 minor planets were taken in conformity with DE403, their coordinates were obtained by numerical integration starting from the osculating elements published in EMP. The relativistic terms due to the Sun were included in the equations of motion. The observations were corrected for gravitational deflection of light and for phase effect. For accounting for the phase effect Lommel–Zeeliger, Akimov [4] and Hapke [5] laws of light scattering were used in different solutions.

Observations of 90 selected minor planets were used in general solution for their orbital elements, orientation parameters and some parameters of phase reduction. The results obtained are discussed in the paper.

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