COMPARISON OF THE PROPER MOTIONS IN DECLINATION OF FOUR CATALOGUES VIA 807 HIPPARCOS STARS

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ABSTRACT. A comparison of four astrometric catalogues with the use of μ_δ for 807 Hipparcos stars is done. Pairwise differences of μ_δ from the catalogues PZT, EOC-2, Hipparcos and new Hipparcos were used to determine their random and systematic errors. The latitude part of ten Photographic Zenith Tubes (PZT data made at 6 observatories) were useful to combine them with the Hipparcos data and to construct the PZT catalogue with μ_δ for 807 stars, which are some of results of PhD thesis (Damljanović, 2007). During last few years, the new Hipparcos, EOC-2 and PZT catalogues have appeared. The Hipparcos one was published in 1997. Also, as a combination of the ground-based and Hipparcos satellite data, many other astrometric catalogues have appeared (TYCHO-2, ARIHIP, etc.) to check and improve the Hipparcos data or to make the densification of data. Usually, the task was to get more accurate coordinates and proper motions of stars than the Hipparcos ones. The useful and big set of data (about 4.4 million optical observations made during last century) are the astrometric observations of latitude and universal time variations; the observed stars are referred to Hipparcos catalogue. Originally, these data were made to determine the Earth Orientation Parameters (EOP), but nowadays for the opposite task (to get the improved coordinates and proper motions of some Hipparcos stars which were observed from the ground over many decades); the EOC-2 catalogue is based on these data. During comparison of four mentioned catalogues, the proper motion differences as a function of coordinates (α, δ), magnitudes and color indices were investigated; determined random and systematic errors of catalogues are relatively small and close to each other.

1. INTRODUCTION

The epoch of the Hipparcos catalogue is 1991.25, and after publishing (ESA, 1997) some other catalogues appeared, as the ARIHIP (Wielen et al., 2001), TYCHO-2 (Høg et al., 2000), EOC-2 (the Earth Orientation Catalogue) (Vondrák, 2004), PZT (Damljanović and Pejović, 2008), re-reduced Hipparcos data (van Leeuwen, 2007), etc.

The interval of Hipparcos satellite data was less than 4 years, and it is not enough for a good accuracy (which is about 1 mas/yr) of proper motions (of double/multiple stars); also, there are some other problems (Vondrák et al., 1998; Vondrák, 2004; van Leeuwen, 2007; Damljanović and Pejović, 2010).

It was clear that combination of Hipparcos/Tycho data with ground-based ones can check and improve the positions and proper motions of common stars. Also, the PZT catalogue is based on more than 0.9 million ground-based observations (made during the time interval 1915.8 – 1992.0) of 807 common PZT/Hipparcos stars (Damljanović, 2007; Damljanović and Pejović, 2008); the accuracy is close to or better than the Hipparcos one.

To check the quality of data, the differences of μ_δ (between PZT, EOC-2, Hipparcos and new Hipparcos) were investigated as a function of coordinates, magnitudes and color indices; all four catalogues have relatively small random and systematic errors which are close to each other (Damljanović and Pejović, 2010).

2. DATA AND RESULTS

Main about the proper motion μ of the star (tangential part on the sphere), μ_α (along the α) and μ_δ (along the δ) is possible to read in the book (Eichhorn, 1974). It is of importance here that the error ϵ_{μ_δ} of μ_δ is proportional to $1/t$ (with long time interval t of ground-based observations it is possible to get good accuracy ϵ_{μ_δ}, better than the Hipparcos one).

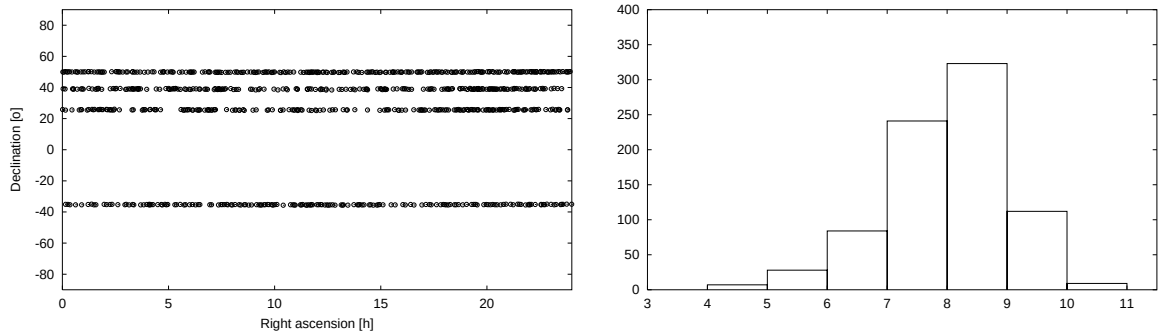

Figure 1: Distribution of 807 stars on the celestial sphere, and distribution of their magnitudes

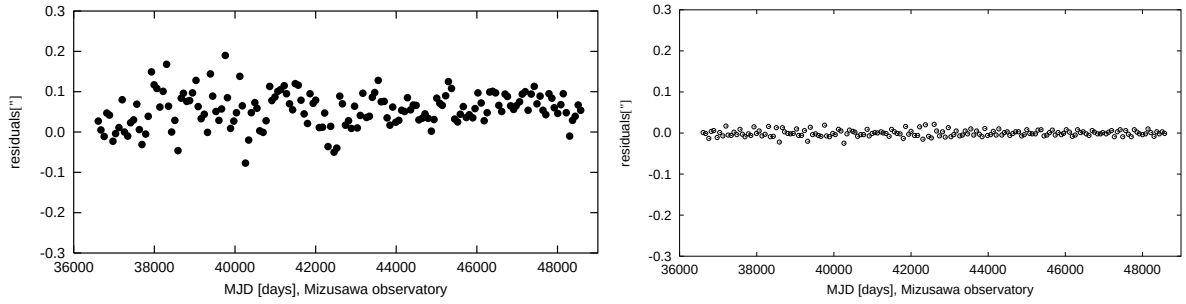

Figure 2: Mean residuals r_i (left) and r_i' (right) in bins of 0.2 years vs. time in MJD; Mizusawa

To construct the PZT catalogue, the latitude variations of optical observations made by 10 PZT instruments (at 6 observatories: Mizusawa, Mount Stromlo, Ondřejov, Punta Indio, Richmond and Washington) together with the Hipparcos data were used (Damljanović, 2005; Damljanović and Pejović, 2005; Damljanović and Pejović, 2010; Damljanović et al., 2006).

Fig. 1 shows the distribution of 807 stars on the celestial sphere (zenith zones of PZT instruments). Also, the distribution of their magnitudes (PZT stars are mostly between 6 mag and 10 mag).

Fig. 2 displays the mean residuals $r_i = -(\varphi_i - \Delta\varphi_i)$ and $r_i' = r_i - se_i$ (in bins of 0.2 years) vs. time in MJD for Mizusawa observatory. The polar motion effect $\Delta\varphi_i$ (calculated by using Kostinski's formula (Kulikov, 1962)) was removed from received data of latitude variations φ_i (Damljanović and Pejović, 2008; Damljanović and Pejović, 2010). The systematic effects se_i removed very well from the values r_i (see Fig. 2, Mizusawa example) to get r_i'.

From PZT observations, the latitude can be calculated by using McCarthy's (1970) formula. If the stars have sufficiently long periods of observations (more than 20 years), the PZT data have got good quality (Damljanović and Pejović, 2008; Damljanović and Pejović, 2010) and good formal errors (close to EOC-2 and new Hipparcos ones, see Fig. 4).

From Fig. 3 (mean differences between PZT data and EOC-2, Hipparcos and new Hipparcos ones, as

catalogue	s_0	p_1	p_2	p_3
PZT-EOC2	168	1 ± 9	-7 ± 6	6 ± 13
PZT-HIP	209	5 ± 12	-5 ± 7	3 ± 16
PZT-NHIP	215	11 ± 12	-3 ± 7	7 ± 17
EOC2-HIP	110	4 ± 6	1 ± 4	-3 ± 8
EOC2-NHIP	132	10 ± 7	4 ± 4	1 ± 10
NHIP-HIP	81	-6 ± 5	-2 ± 3	-4 ± 6

Table 1: Comparison of μ_δ of 807 stars, from Hipparcos, re-reduced Hipparcos (NHIP), PZT and EOC-2, to get formal and systematic errors (in 0.01 mas/yr).

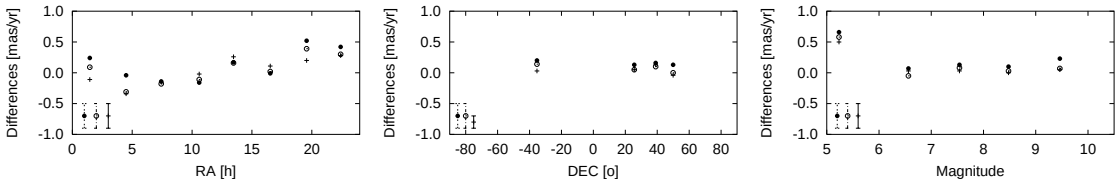

Figure 3: Mean proper motion differences (with a typical mean error bars) of 807 stars, as a function of α, δ and magnitude, between PZT data and: the re-reduced Hipparcos (solid circle), Hipparcos (open circle) and EOC-2 ones (+)

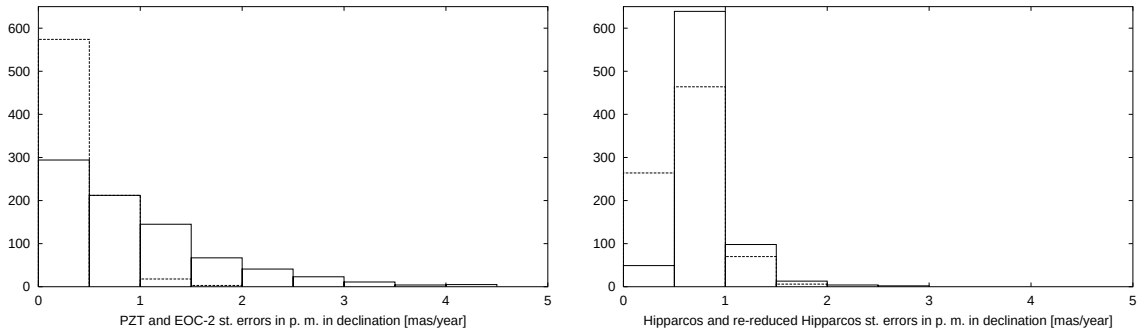

Figure 4: Distribution of standard errors in proper motions in declination for 807 stars: PZT (solid lines), EOC-2 (doted lines), Hipparcos (solid lines) and re-reduced Hipparcos (doted lines)

the function of coordinates and magnitude) is evident that PZT results are on the average very close to those of the three other catalogues (Damljanović and Pejović, 2010). A typical mean error bars of mean values, but not standard deviations in the bins, are shown. The values of standard deviations are close to the values s_0 (see in Table 1), respectively.

The formula $p_1 + p_2(m - m_0) + p_3(B - V) = \Delta$ (according to Ivanov and Yatsenko (2003)) and LSM (the Least Squares Method) were used to determine random and systematic errors of four catalogues. The calculated values of p_1, p_2 and p_3 (which describe the systematic part of differences Δ) are presented in Table 1, m are the magnitudes and $B - V$ color indices. s_0 is the random part of Δ (the sum of random errors of both of the two treated catalogues) and the error of unit weight of the solution of the system given by last equation.

The values of Table 1 are small. It means, the random and systematic errors of values Δ are very small, and μ_δ data of all four catalogues are close to each other (μ_δ data have got a high accuracy). So, there is no significant relationship between Δ and $m - m_0$ (or $B - V$).

3. CONCLUSIONS

It is possible to satisfy the requirements of the modern astrometry by using some of ground-based data, as it was the case of PZT observations to construct the PZT catalogue. And to check the present reference frame (Ron and Vondrák, 2001); the Hipparcos catalogue data materialize that frame.

The PZT catalogue data, the values of μ_δ for 807 stars (Damljanović and Pejović, 2008), were compared with the EOC-2, Hipparcos and new Hipparcos data. The consistency is good.

The procedure of determining random and systematic errors for 807 common stars of four catalogues by pairs (PZT, EOC-2, Hipparcos and new Hipparcos), according to Ivanov and Yatsenko (2003), shows that it is not find a significant relationship between the differences Δ (of μ_δ) and magnitudes and color indices. So, all catalogues have high accuracy of μ_δ. The random and systematic errors of μ_δ are small and close to each other. Also, it is an independent checking of μ_δ from the catalogues EOC-2, Hipparcos and new Hipparcos.

The PZT catalogue data are available at the URL:http://saj.matf.bg.ac.rs/177/pdf/Table2.dat.

Acknowledgements. Author performed his work as a part of the Projects No 146004 “Dynamics of celestial

bodies, systems and populations" supported by the Ministry of Science and Technological Development of R. Serbia.

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