Proc. VI Serbian-Bulgarian Astronomical Conference, Belgrade 7-11 May 2008,
Eds. M. S. Dimitrijević, M. Tsvetkov, L. Č. Popović, V. Golev
Publ. Astr. Soc. "Rudjer Bošković", No. 9, 2009, 307-310

CLASSICAL OBSERVATIONS OF LATITUDE AND THE IMPROVED REFERENCE FRAME

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Abstract. It was decided at the General Assembly of IAU in 1997 at Kyoto that the International Celestial Reference Frame (ICRF) materializes the International Celestial Reference System (ICRS) from the beginning of 1998, and the HIPPARCOS Catalogue was accepted as the primary representation of the ICRS in optical wavelengths. HIPPARCOS is one of the two catalogues (another one is Tycho) of ESA mission, and it gives for each of 118218 stars: very precise positions, proper motions, parallaxes, etc. However, nowadays we can see that the proper motions of some stars (mostly double or multiple) have problematic values because the mission was too short, less than four years. To improve these proper motions, it is possible to use also the ground-based long history optical observations of latitude/universal time variations (near 4.4 million observations of more than four thousand stars were collected), and the reference frame can be more stable. The goal is the Earth Orientation Catalogue (EOC). In this paper, we present some results of proper motions in declination of HIPPARCOS stars observed with Photographic Zenith Tubes (PZT) throughout the 20th century.

1. INTRODUCTION

The standard errors of Hipparcos stars positions are near 1 mas at the epoch of the catalogue (1991.25), and the st. errors of its proper motions are near 1 mas/yr. Nowadays, a few new catalogues appeared with better accuracy of proper motions than the Hipparcos one. The main problem of Hipparcos proper motions accuracy is the period of Hipparcos satellite observations which was shorter than four years; it is not enough to get a good accuracy of proper motions for some stars (as double or multiple ones). Also, some regions of Hipparcos Catalogue are with big errors of proper motions data. Nowadays, there are near 15 years after the epoch of Hipparcos Catalogue (1991.25), and the errors of Hipparcos proper motions (near 1 mas/yr) introduce the error of calculated apparent positions of Hipparcos stars of about 15 mas, which is near the ground-based error of observed positions and one order bigger than the errors of Hipparcos positions. So, the astro-geodesy observations need better accuracy of proper motions than Hipparcos ones. Some investigations started during last decade by using useful ground-based observations (to get improved proper motions better than Hipparcos ones) and produced new catalogues: the ARIHIP (Wielen et al. 2001), EOC-2 (Vondrak 2004), etc.

The ground-based astrometric observations of latitude and universal time variations, covering the interval 1899.7-1992.0 and made in accordance with the Earth rotation programmes, were included into the investigations to improve the accuracy of proper motions, also. Here, we use the latitude variations of 10 PZT plus the OA00 (Ron and Vondrak 2001) solution of the EOP. Our method is different than that used for the EOC-2. The PZT data are: 3 at Washington, 2 at Mizusawa and Richmond, 1 at Ondrejov, Punta Indio and Mount Stromlo.

We determined the corrections of Hipparcos proper motions in declination with accuracy similar to accuracy of proper motions of ARIHIP and EOC-2.

2. DATA, CALCULATIONS AND CONCLUSIONS

The proper motion of the star (tangential part on the sphere) can be separated into two parts, along the coordinate right ascension and along the declination (the radial velocity is normal on both, and all together give the motion of the star in the space). Here, we are using PZT data, the linear model and the Least Squares Method (LSM) to calculate the corrections to Hipparcos proper motions in declination. To determine the proper motion in declination, it is necessary to have at least two positions (declinations, in the same system) of the same star for the epoch t1 and t2, respectively. The error of proper motion in declination is in line with the standard errors of mentioned declinations, but proportional to 1/t (Eichhorn 1974). It means, with long observations interval t, we can get good accuracy of proper motion in declination (better than the Hipparcos one) even Hipparcos accuracy of star positions is better than ground-based one. It is of importance for this work.

During each year of the observed interval, each PZT star was observed from a few until few hundred times. The latitude accuracy from one PZT star observation is mostly between 0.1 and 0.2 arcsec, but a few decades long time interval and a lot of observations of each star during each year of that interval are useful for calculations of better accuracy (than Hipparcos one) of proper motions in declination of common PZT and Hipparcos stars. The combination of latitude observations with Hipparcos one (for the moment 1991.25) can give us better results than only PZT latitude data. The accuracy of PZT data is about one order better than 0.2 arcsec for the averaged (over near one year observational interval) values of latitude variations.

In the case of the Punta Indio – Mount Stromlo stations (common stars), we used the PZT data (latitude variations) of both stations, with nearly the same latitude (-35.3 arc degrees). Similar situation is for the PZT stations Washington - Mizusawa.

We used the latitude PZT variations to improve Hipparcos proper motions in declination (Damljanović, 2005; Damljanović and Pejović, 2005), and the main PZT formula from the paper of McCarthy (1970). The polar motion part was calculated and removed from our input data (PZT latitudes) by using the Kostinski formula (Kulikov 1962). The polar motion coordinates x and y are from the EOP solution OA00 (Ron and Vondrak 2001). Also, the systematic variations (local, instrumental, etc.) for each instrument were calculated and removed from our input data. So, without the polar motion and systematic variations (local, instrumental, etc.), our input data (for LSM) are mostly with catalogue errors. It was our intention, in line with the connection (Vondrak et al. 1998) between the correction of proper motion in declination and the latitude data (without polar motion part and mentioned systematic variations). The main steps of our calculations, by using LSM with the linear model, are presented in few published papers (Damljanović, 2005; Damljanović and Pejović, 2005). Our calculated corrections to the Hipparcos proper motions in declination of common PZT/Hipparcos stars are in line with the epoch of Hipparcos Catalogue (1991.25). Input latitude data and the Hipparcos one are with suitable weights (Damljanović et al., 2006).

For example, the calculated correction to common PZT RCP/RCQ (Richmond) and Hipparcos star H9859 (5.99 mag) is +0.12 mas/yr with st. error 0.26 mas/yr. There are 40 input PZT points (about 40 observed years) plus the Hipparcos one, and the points are with weights. So, our proper motion in declination for H9859 is -14.42 mas/yr with st.error 0.26 mas/yr.

From EOC-2, it is -13.98 mas/yr with st. error 0.20 mas/yr.

From HIPPARCOS, it is -14.54 mas/yr with st. error 0.66 mas/yr.

The similar results are for the other PZT/Hipparcos stars. Our calculated corrections can be added to the Hipparcos values and get better values of proper motions in declination than the Hipparcos ones.

We calculated the proper motions in declination of 807 PZT/Hipparcos stars observed with 10 PZT instruments. Our results are in good agreement with the EOC-2 ones. The differences between our solutions and EOC-2 ones with number of observed years are mostly less than 1 mas/yr. In general, if the PZT stars are observed more than 10 years our results are better than the Hipparcos ones. For good results, it is necessary to have the input data with long interval of observations, as we remarked at the beginning of this paper.

It is evident that PZT data are useful and can improve the reference frame (via improvement of proper motions in declination of Hipparcos stars).

Acknowledgements

This work is a part of projects No 146004 “Dynamics of celestial bodies, systems and populations” and No 146022 “History and Epistemology of Natural Sciences” (Ministry of Science and Technological Development of Republic of Serbia).

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