FIRST STEPS TO RE–OBSERVATION OF THE HIPPARCOS/TYCHO STARS BY GROUND-BASED AUTOMATIC AMCs

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ABSTRACT

The principal peculiarities and technical possibilities of the Mykolayiv automatic Axial Meridian Circle (AMC) permit to use it efficiently for the maintenance and densification of the Hipparcos and Tycho catalogues, for increasing of the linking accuracy between the Hipparcos and ICRF reference frames. From 1996 the observation of 12–14 magnitude secondary reference stars from the GSC in the fields around the 400 extragalactic radiosources for declination zone from $+90°$ to $-20°$ were started with the AMC. The positions of primary reference stars were selected from the Hipparcos Catalogue. Additionally, it is observed the Tycho stars in the selected fields. The observations are carried out by CCD method of short strips. At present, observations of about 2060 strips around 209 ERS with 65000 stars from the GSC and Tycho, and 3100 strips with the Hipparcos stars. The observation and current reduction are followed. It needs about three observation years for efficient accuracy of about 0.02 arcsec.

Keywords: Astrometry, reference frames, meridian circles.

1. INTRODUCTION

In 1997 IAU will approve the new, non-rotating, celestial reference frame ICRF based on VLBI observations of extragalactic radio sources (ERS). The Hipparcos Catalogue of 118 218 selected stars is considered as a representative of ICRF in optical domain. Having the axes satisfactorily in agreement with ICRF at the epoch 1991.25, the Hipparcos frame will lose this link progressively due to uncertainties of the Hipparcos proper motions. At J2000 star positions in the Hipparcos Catalogue will be worse at about 20 mas, in the Tycho Catalogue at about 40 mas (Høg 1995). Thus, the high priority directions of activity should be the reobservation and densification of the Hipparcos and Tycho catalogues and therefore the maintenance of the high level link between optical/radio reference frames.

As a practical research of these problems a step will be done to provide a reliable base for positions of faint stars up to 15 magnitudes located in one-degree fields around the ICRF ERS using meridian (CCD) observations.

2. CURRENT RESULTS WITH THE AXIAL MERIDIAN CIRCLE

The automatic AMC was put into operation in 1995. From January 1996 regular observation of stars located around the ERS was started. There are some papers described different elaboration stages of the AMC (Shornikov et al. 1990; Shornikov et al. 1991; Kovalchuk et al. 1996). It is presented now only short AMC description.

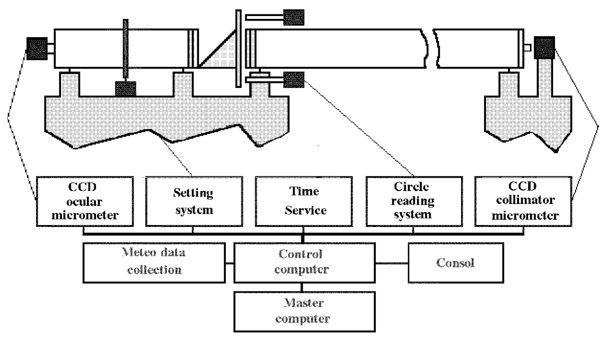

Figure 1. The Mykolayiv AMC with the Computer Control System.

The AMC scheme includes a horizontal telescope (D = 180 mm, F = 2480 mm) in the prime vertical which can rotate around its axis (Figure 1). The objective is connected with a 45-degrees citall pentag. The second extremity is connected with an ocular micrometer. During star meridian passage diagonal pentag mirror reflect the stellar light to micrometer. Another light beam from mark of fixed vacuum collimator (D = 180 mm, F = 12360 mm) in the prime vertical go to micrometer through the central hole of pentag. So, it is possible to determine coordinates of celestial bodies relative to the fixed collimator direction and check an instrumental parameters.

The AMC was furnished with setting and reading systems, meteorological data collection, time service, a CCD (288 × 256) ocular micrometer and computer control system (CCS). The software of CCS had a sufficient number of routines for control and data handling. For these purposes an observer integrated enviromental (IE) was elaborated. The IE provided connection and execution routines for telescope control, data acquisition and handling, preparation of night input data, keeping book of observations etc. It was possible to observe in automatic, manual and special modes, determine the parameters of the telescope (orientation, collimation, flexure, circle divisions errors), test the telescope devices and units.

For observation with automatic AMC a short strip method was elaborated. According to it the AMC was installed to a zenith distance of field around ERS and all stars from GSC and Tycho up to 15 were observed by CCD micrometer during four minutes long (one angular degree in RA) by diurnal moving. The instrumental position was measured before and after a strip without the instrument moving relative to a fixed collimator. Thus it was possible to determine all shifts of the immovable AMC and CCD together. After that, the AMC was installed to another zenith distance and a Hipparcos star was observed during 50 seconds together with auto-collimation measurements. So, a position of stars located around ERS can be determined relative to reference Hipparcos stars. It was a classical procedure of a differential observations. Another way is to determine a star positions around ERS using a Tycho stars located in short strip as reference one. Short strip method permits to reduce an influence of refraction anomalies, instrumental shifts and deformation during observation based on the AMC stability. Also it is possible a regular distribution of short strips on the sky. So, the short strip method has some advantages of small field differential astrometry in comparison with long strips.

Investigations of the AMC parameters showed (Pinigin et al. 1995a; 1995b):

(a) horizontal flexure was derived in the temperature range from $+12°$C to $+19°$C. It was negligible and consisted of: -0.037 ± 0.042 arcsec;

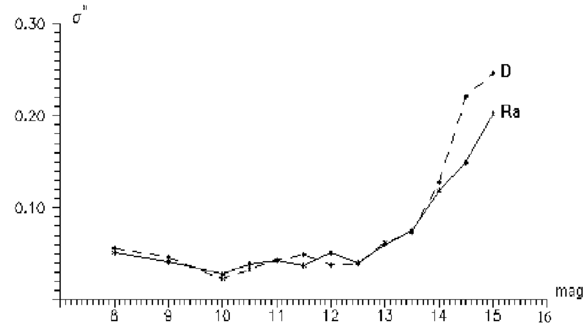

Figure 2. Positional error (arcsec) of observation (Ra and D) by CCD micrometer with brightness of star.

(b) collimation was stable with time and with temperature and can be described by the formula $C = C_0 + a \cdot t$, where t [C] was the environmental air temperature, $C_0 = 12.705 \pm 0.099$ arcsec, $a = 0.026 \pm 0.008$ arcsec;

(c) variations of collimator inclination with the temperature were 0.09 ± 0.04 arcsec per degree C;

(d) CCD limit magnitude - 15; it was possible with computer control to observe 1500-2000 stars per hour. Figure 2 shows a variations of positional error (arcsec) of single observation (dec and RA) by CCD micrometer with the brightness.

Estimates of the mean error of a single observation with the AMC were based on a comparison of the individual observations of the same stars observed during observational period 1996 in declination range from $-5°$ to $+60°$:

$$\mathrm{RA}\ (-) = \pm 0.015 \sec^{0.34}(D) \cdot \sec^{0.65}(Z)$$

$$\mathrm{Dec}\ (-) = \pm 0.15 - -0.20\ \mathrm{arcsec}$$

The positions of reference Hipparcos stars were compared with their positions in the PPM catalogue for the purpose of studying systematic differences. Figure 3 for right ascention (RA) and Figure 4 for declination (dec) show the variation of RA mean systematic differences $(O-C)_\delta \cdot \cos(\delta)$ and variation of D mean systematic differences $(O-C)_\delta$ for every declination zone in steps of 5 degrees. The AMC trial for 1996 system showed a sufficient stability with the time and temperature. The variations of instrumental system were not more than 0.09 arcsec (RA) and 0.05 arcsec (dec) in temperature range 31° C. Also comparison with similar differences from CAMC, Bordeaux MC, PMC and HMC showed good agreement of the mean variations with the accuracy of the mean error on the level of about 0.05 arcsec (Kirian and Pinigin, 1993). This enabled us to reach a conclusion about small influence of instrumental parameters.

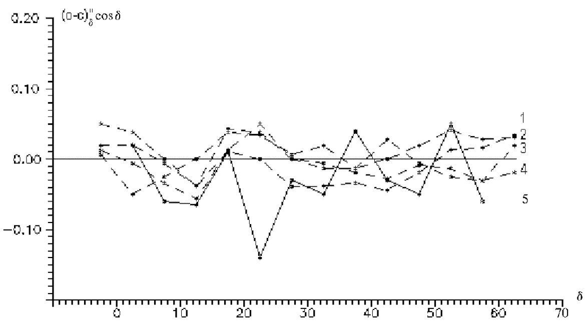

Figure 3. Comparison of RA mean systematic difference (O-C)$_\delta$ cos δ in the sense of Cat -FK5 found with CAMC (1), Bordeaux MK (2), PMC (3), HMC (4) and AMK (5).

3. OBSERVATION

From 1996 the observation of 12–14 magnitude secondary reference stars from the GSC in the fields around the 400 extragalactic radiosources for declination zone from +90 to −20 were started with the AMC (Pinigin et al. 1995). Just now it was observed with the AMC about 2060 strips around 209

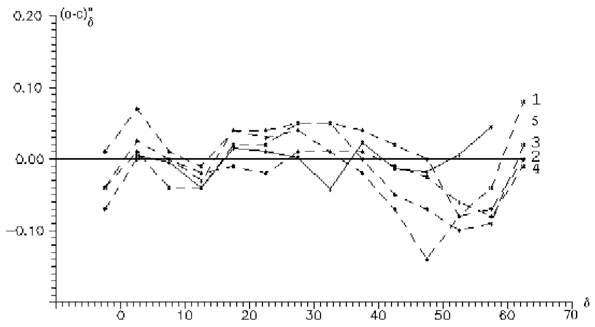

Figure 4. Comparison of Dec mean systematic difference (O-C)$_\delta$ in the sense of Cat-FK5 found with CAMC (1), BordeauxMK (2), PMC (3), HMC (4) and AMC (5).

ERS with 65000 stars from the GSC, Tycho and 3100 strips with the Hipparcos stars. The observation and current reduction of strips are carried out by differential classical procedure at first. Later we intend to use the Tycho Catalogue stars as reference one.

The results wich are expected at the end of this program: (a) a new positions of the Hipparcos and Tycho stars in selected fields; taking into account the amount of clear nights in Nikolaev (about 120) and efficiency of automatic CCD AMC it needs nearly three years for receiving the position accuracy of about 0.02 arcsec; (b) differential position catalogue of stars from GSC in the fields around ERS.

4. CONCLUSIONS

(1) The Mykolayiv AMC showed high trial stability and accuracy in systematic sense. It will permits us to reduce an influence of instrumental errors to the level of about 0.02 arcsec.

(2) The sufficient results with AMC allow to use it for reobservation such large catalogues such as Hipparcos and Tycho. More efficient results could be achieved with modern large CCD (1024 × 1024), with observations of up to 1 million stars of fainter magnitudes per year.

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