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POSITION DETERMINATION OF 12–14 MAGNITUDES STARS IN THE SELECTED FIELDS AROUND EXTRAGALACTIC RADIO-SOURCES WITH THE AUTOMATIC AMC

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ABSTRACT. Observational results are discussed for the Mykolayiv axial meridian circle (AMC) with computer control. Based on two years of observations, investigation of right ascensions and declination mean systematic differences (in the sense Cat–HC) was made. Negligible influence of instrumental errors and expected accuracy of about 0.″02 – 0.″05 are demonstrated.

1. INTRODUCTION

1.1 Design. The AMC scheme includes the horizontal telescope in the east-west direction which can rotate around its axis in shoe-like bearings. The objective extremity is fixed to the 45° cital prism. The other extremity is connected with an ocular micrometer. The star light is reflected from the diagonal prism mirror and goes to the ocular micrometer. Another beam of light goes to the ocular micrometer from the mark of long-focus autocollimator in the prime vertical through the central hole of the prism. So, it is possible to determine the coordinates of celestial bodies with respect to the position of immovable autocollimator and to check the instrumental parameters.

1.2 The principal components and technical data of the AMC.

1) Horizontal tube: aperture 180mm, focal length 2480mm, scale reading in the image plane 1″ = 12.02μm; it is located in the V-bearings of conventional type and coated of insulation against temperature gradients. The tube is connected with the star ocular micrometer and prism.

2) CCD ocular micrometer is equipped with the CCD array 288×256, pixel size of 24×32 μm and cooled down to −60° C; mean error of artificial mark reading is 0.″02, magnitude limit 15^m, observation of sky strip with width of eight arcminutes up to 80° declination and length of four minutes, using control computer.

3) Prism unit was made from the cital cylinder of 180mm diameter, with a central hole of 60mm diameter, truncated at 45°.

4) Divided glass circle with the reading system: diameter 420mm, division interval 5′, four reading microscopes with the mean error of 0.″02 and reading time 16 sec; there are two additional microscopes for automatic determination of graduation errors and checking their stability.

5) Telescope setting system is assured by means of a step motor: positioning accuracy 10″, rate 1.5 degree/sec; it provides the visual control by a TV microscope.

6) Autocollimator with the CCD micrometer in the prime vertical: objective aperture 180mm, focal length 12360mm, scale reading in the image plane $1'' = 59.92\mu m$; the tube is vacuumed to get rid of the refraction anomalies along the horizontal light path; CCD autocollimator micrometer has an error of artificial mark reading 0.″02.

7) Time service is based on the Rb beam clock and used for keeping the time scale during observations and its synchronization by help of short and long wave receivers; accuracy for keeping of time scale is 0.5μsec/day.

8) Meteorological data collection unit (MDC) is intended for measuring ambient temperature inside and outside the AMC buildings, pressure and humidity. It is possible to measure the temperature of foundation for checking the AMC position; the reading accuracy of the temperature, pressure and humidity is 0.05°C, 0.05mm Hg, and 1mm Hg, respectively.

9) Computer control system (CCS) provides observations with the AMC in automatic and manual modes, telescope setting, divided circle and micrometers of tube and autocollimator readings, collecting the meteorological data in real-time, data preparation, handling and keeping. CCS includes control and master PC computers of type PC-486 connected in local net with the information exchange rate of 1Mbit/sec on distance of 300m.

10) AMC is installed on the special foundation and located in two buildings. The main building (with the AMC horizontal tube and autocollimator objective) has a slit opening in a roll-off building, the second one (with the autocollimator micrometer on a pillar) has a solid roof. There is a separate control/observer room.

1.3 Software. The software of CCS consists of a number of routines for control and data handling. For these purposes an observer integrated environment (IE) was elaborated. The IE provides night input data preparation; determination of instrumental parameters; testing the telescope devices and units (orientation, collimation, flexure, circle divisions errors); observation in automatic and manual modes; display information about the current status of observational processes; handling and keeping of observational data.

1.4. Analysis of AMC results. The investigation of the AMC parameters showed that:
- horizontal flexure was negligible, being only $-0.''037 \pm 0.''042$;
- collimation was stable in time and with temperature and it can be approximated by the formula $C = C_\circ + a \cdot t$, where t [C] is the air temperature, $C_\circ = 12.''705 \pm 0.''099$, $a = 0.''026 \pm 0.''008$;
- variations of collimator inclination with the temperature were $0.''09 \pm 0.''04$ per 1°C;
- CCD limiting magnitude is 15^m; it is possible to observe, with the computer control, about 1500–2000 stars per hour.
- Estimates of the mean error of a single observation with the AMC were based on comparison of the individual observations of the same stars of 8–10 magnitudes observed during observational period 1996 in declination zone from −5 to +60 degrees:

$$\varepsilon_\alpha cos\delta = 0.''12 sec^{1.2}z$$

$$\varepsilon_\delta = 0.''13 sec^{1.1}z$$

1.5. AMC observation method. For observation with automatic CCD AMC a short strip method was elaborated. The AMC is set to the zenith distance of a field around extragalactic radio sources (ERS) and all stars from GSC, TC (up to 15) are observed by CCD during four minutes (one degree in right ascension). Position of the instrument is measured before and after the strip, without moving the instrument relative to the fixed collimator. It permits to determine all shifts of the immovable AMC and CCD together. After that, the AMC is set to another zenith distance and a HC star is observed during 50 seconds, together with the autocollimation measurements. Thus, the positions of stars located around ERS can be determined relative to reference HC stars. This is a classical procedure of differential observations. Another way is to determine a star positions around ERS using TC stars located in a short strip as a reference. Short strip method permits to reduce the influence of refraction anomalies, instrumental shifts and deformation during the observation. It also to enable a regular distribution of short strips on the sky. So, the short strip method has some advantages of small field differential astrometry.

2. CURRENT OBSERVATIONAL PROGRAMME.

The CCD AMC with computer control was put into operation at the Mykolayiv astronomical observatory in 1995. Since 1996 the observation of intermediate reference stars in the fields around 250 north ERS for declination zone from +70 to -20 and in the 12–14 magnitude range started. The positions of the reference stars, selected from the GSC, were provided in the Hipparcos system for increasing the optical/radio reference frames linking accuracy. The AMC list of observed objects comprises:

1)	Intermediate reference stars from GSC in selected areas	20000
2)	Primary reference stars from HC	2000
3)	Additional stars from TC	5000
4)	Selected minor planets	20

3. OBSERVATIONAL RESULTS.

So far, about 2380 strips around 220 ERS (with stars from the GSC, TC) and 3310 strips (with the HC stars) were observed with the AMC. At first, the observation and current reduction of strips are carried out by differential classical procedure. Later we intend to use the TC stars as a reference. The present results are displayed in Fig. 1 (right ascension) and Fig. 2 (declination). They show the variation of the mean systematic differences $(O-C)_\alpha cos\delta$ and $(O-C)_\delta$ for each declination zone in steps of 5 degrees. The errors of the mean systematic differences $(O-C)$ range from 0.″03 to 0.″05. The AMC 1996 system (in the sense AMC–FK5) shows a sufficient stability with time and temperature. For instance, variations of instrumental system in temperature range 23°C were smaller than the internal accuracy of the mean systematic differences. A new reduction (in the sense AMC–HC) brings a marked diminishing of the systematic differences (Figs. 1, 2). It enables to conclude that there is a negligible influence of the AMC instrumental parameters in the reduction in the Hipparcos Catalogue system and that it is possible to reach the expected enhanced catalogue AMC accuracy.

4. CONCLUSIONS

The Mykolayiv AMC shows high stability and accuracy of instrumental system during current observation. It allows to conclude about the possibility of the reduction of the final differential catalogue, with negligible influence of instrumental errors and expected accuracy of 0.″02 – 0.″05. It requires about three years of observation for creation of the final AMC catalogue in 1998.

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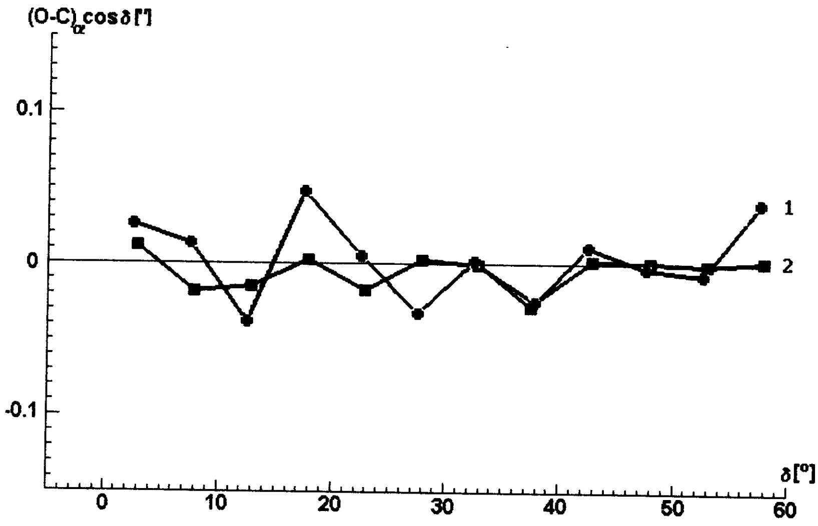

Fig 1. The variation of Ra mean systematic differences $(O-C)_\alpha \cos\delta$
1-(AMC-FK5), 2-(AMC-HC)

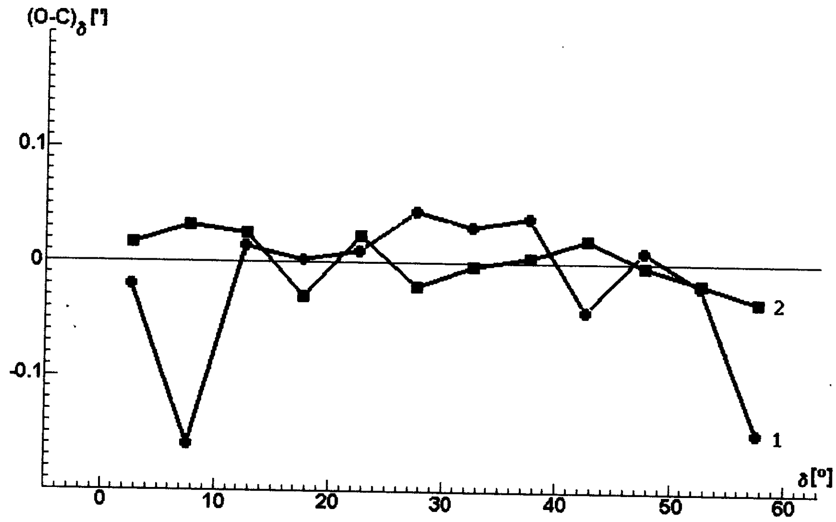

Fig 2. The variation of Dec mean systematic differences $(O-C)_\delta$
1-(AMC-FK5), 2-(AMC-HC)

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