

DOI: <http://dx.doi.org/10.18524/1810-4215.2016.29.85182>

THE EQUATORIAL COORDINATES AND B-MAGNITUDES OF THE STARS IN THE SOUTHERN HEMISPHERE ZONES BASED ON THE DIGITIZED ASTRONEGATIVES OF FON PROJECT AT THE ULUGH BEG ASTRONOMICAL INSTITUTE

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ABSTRACT. FON (Russian abbreviation of the Photographic Sky Survey) were carried out at 6 observatories. The Kitab Observatory (KO) of Ulugh Beg Astronomical Institute (UBAI) of the Uzbek Academy of Sciences (UzAS) was involved in this project from 1981 to 1996. For the observations the Double Astrograph of Zeiss (DAZ, D/F = 40/300, 69"/mm) was used. On the FON project about 2600 photographic plates were exposed. In October, 2015 digitization of these astroplates were started using EPSON Expression 10000XL flatbed scanner with the spatial resolution of 1200 dpi and completed in June, 2016. The first stage of the work is the processing of the 2000 photographic plates in zones of the southern hemisphere with the declination between 0 and -20 degrees. The 1704 plates have already been processed. The equatorial coordinates α , δ of stars and galaxies were determined in the system of the Tycho2 catalogue and the B-magnitudes in the system of the photoelectric standards. UBAI UzAS, Tashkent (Uzbekistan), ASU, Andijan (Uzbekistan), WHO, Essen (Germany), RI NAO, Nikolaev (Ukraine), MAO NASU, Kyiv (Ukraine) have taken part in the processing of the digitized images. For the data reduction the MIDAS package and software, developed in the MAO NASU were used. Based on the results of the processing of the astronegatives in the sectors of right ascension from 0 hours to 24 hours and declination from -20° to 0° the internal errors of the catalogue were estimated. The errors calculated for all stars are 0.17" and 0.18^m respectively. For the stars brighter than 14 magnitude the errors are 0.08" and 0.07^m for the equatorial coordinates and B-magnitudes respectively.

Keywords: photometric – methods: data analysis – catalogs, virtual observatory tools – astrometry – techniques

1. Introduction

The idea of the project "A photographic survey of the northern sky" (FON) was initiated by the main Astronomical Observatory of National Academy of Sciences of Ukraine (MAO NASU, Ukraine) [Kolchinsky, 1977]. The observatories of the former Soviet Union, such as Goloseevo, Zvenigorod, Dushanbe, Abastumani, Zelenchuk and Kitab realized this project using identical astrographs (with a diameter of 400 mm lens and a focal length of 2000 mm or 3000 mm) produced by the company Carl Zeiss Jena (GDR). On the Kitab observatory was installed a double Zeiss astrograph (F = 3000 mm, field of view 5.5° x 5.5° and scale 69"/mm). The photographing of the sky (from -20° to +30°) was done with a shift of the centers of photographic fields in 2 degrees on the declination, and with a difference of distances in 4 degrees on the right ascension between the centers of adjacent fields. The observation schema is represented in the Figure 1. Each field was photographed with two exposures (the long one: from 40 to 60 minutes and the short one: from 40 to 60 seconds) on the same photographic plate with the shift on both coordinates. The duration of the long exposure was selected in such a way to obtain images of stars down to 16-17 magnitude. On the Kitab observatory the photographic observations for the FON project were carried out from 1981 to 1996. More than 2600 photographic plates were received. In the observations were involved E. Rakhmatov, X. Rakhmatov, E. Mirmahmudov, L. Bash-tova, J. Ivanov and others. In October, 2015 all astronegatives were brought from Kitab observatory to Tashkent and systematized as an archive of the glass library of the AI UzAS. Since November 2015 have been scanned more than 2000 astronegatives in the areas from -18° to 0° using

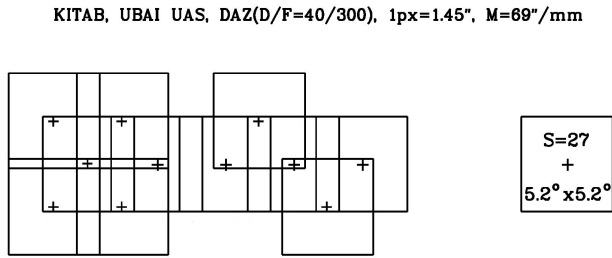


Figure 1: The scheme of the overlapping fields of the astronegatives for the Kitab's part of the FON project.

the Epson Expression 10000XL flatbed scanner and its base software product designed for the scanning with a spatial resolution of 1200 dpi and the size of fields up to 13000 x 13000 pixels (one pixel is equal 1.45"). By this time, for the Kyiv's part of the FON project in MAO NASU was developed a special software in LINUX/MIDAS/ROMAFOT environment, which has already been tested in various works (Andruk, 2005a; Andruk, 2005b; Andruk, 2007; Andruk, 2010; Eglitis, 2016a; Eglitis, 2016b; Kazantseva, 2015; Protsyuk, 2014a; Protsyuk, 2014d; Protsyuk, 2015; Vavilova 2012a; Vavilova, 2012b; Vavilova, 2014; Yatsenko, 2011; Yizhakevych, 2014; Yizhakevych, 2015; Yizhakevych, 2016). For all scans of the Kitab's part of the FON project were already received rectangular coordinates and instrumental stellar magnitudes of all registered objects and compiled preliminary catalogues of stars for all zones. The final result – the common catalogue will be obtained from the processing of single scans without rotating of the plates by 90°, which allows to save resources for storing and processing information twice without the compromising the accuracy of the results. The principles and steps of the processing of digitized photographic plates, which were briefly summarized in Andruk, 2015c, are already successfully applied for the processing of all scanned images of the Kitab's part of the FON project.

2. The progress in the realisation of the Kitab's part of the FON project

The common approach to the study of accuracy characteristics of scanners was implemented in the works (Golovnya, 2010; Protsyuk, 2014b; Protsyuk, 2014c). In this work for the digitization of the astronegatives was used the Epson Expression 10000XL scanner. The investigations of its astrometric and photometric characteristics were described in the works (Muminov, 2013; Muminov, 2014, Muminov, 2016). To obtain a star catalogue of equatorial coordinates and B-magnitudes were used the methods and programs for the processing of scans and the creating of catalogues presented in the works (Andruk, 2014; Andruk, 2015b; Andruk, 2016a; Andruk, 2016b; Pakuliak, 2016). The equatorial coordinates of stars and galaxies were obtained in the system of Tycho2 catalogue and the photographic B-magnitudes in the system of photoelectric standards (Andruk, 1995; Kornilov, 1991; Mermilliod, 1991; Relke, 2015). So far (September 2016) were processed N=1704 plates in ten areas, on which after mutual identifications for overlapping areas of the plates were found more than K=11.6 millions stars and galaxies from more than L=116

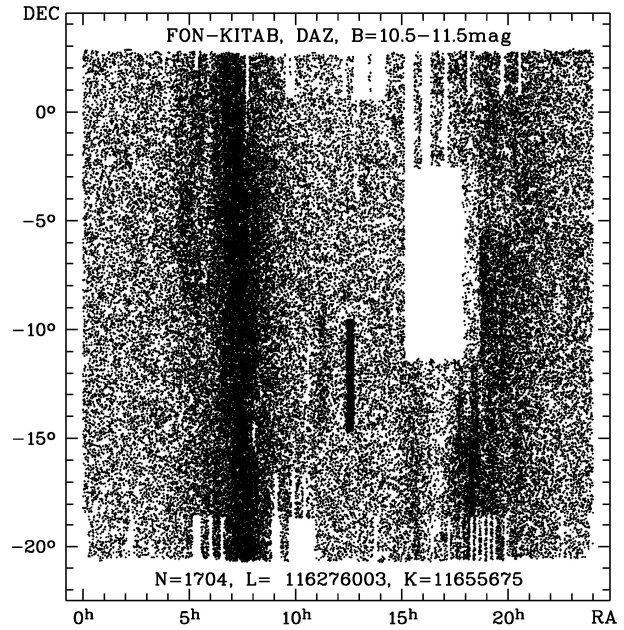


Figure 2: The progress in the processing of plates of the Kitab's part of the FON project.

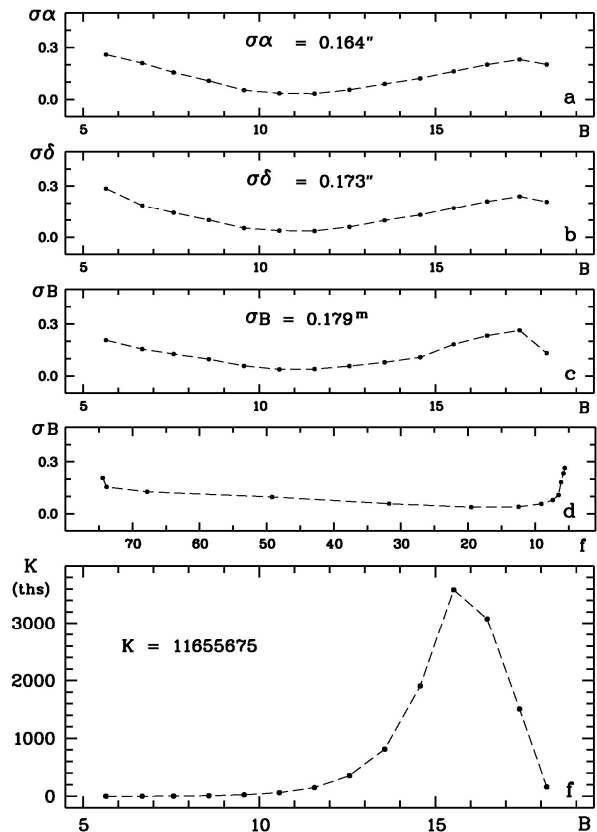


Figure 3: The errors of the determining of the equatorial coordinates and B magnitudes.

millions registered objects. These data for all zones are presented in the Figure 2. In the Figure 3 are given values of errors of the determined equatorial coordinates (a, b) and errors of the B-magnitudes (c, d) as well as the histogram of the distribution of stars and galaxies by magnitudes (f). Based on the results of the processing of these astronegatives were estimated internal catalogue errors. The mean

errors for all stars are 0.17" and 0.18^m (for stars brighter than 14 magnitude -0.08" and 0.07^m) in equatorial coordinates and magnitudes respectively.

6. Conclusion

The scanning, processing and creation of star catalogue in areas from -20 to 0 degrees of the Kitab's part of the FON project are planned to be finished by the end of 2016. The coordinates of stars and galaxies will be received in the system of Tycho-2 catalogue (mean epoch, 1984.9), B-magnitudes in the system of photoelectric standards. As photometric standards for the building of the characteristic curves of individual astronegatives were used photoelectric B-magnitude of stars from special catalogues. The convergence between the calculated and referenced positions is $\sigma_{\alpha\delta} = \pm 0.056''$ and the convergence with photoelectric stellar B-magnitudes is equal $\sigma_B = \pm 0.19^m$. Differences relative to the UCAC4 catalogue are equal $\sigma_{\alpha\delta} = \pm 0.29''$.

The star catalogue of positions and B magnitudes of the Kitab's part of the FON project will be posted on the web-page of MAO NASU and website of UkrVO. The catalogue of stars and galaxies down to $B \leq 17.5^m$ includes equatorial coordinates α , δ on the individual epoch of the observations and on the Equinox 2000, stellar magnitudes in the B system, as well as the errors of the determinations of these values, the number of definitions and information in the form of average values for the diameter of star images (f) and intensity values in the center of the object images (I_c). Also in the catalogue will be included an additional information from the UCAC4 catalogue: the proper motions and stellar magnitudes in F, B, V, R, I bands (Zacharias, 2013).

Interim results on the progress and outcome of the creating a FON-Kitab catalogue (as well as works that were performed using FON software packages) were reported on the conferences Pulkovo-2013, Pulkovo-2015 (Russia, St.-Petersburg), Gamov-2016 (Odessa, Ukraine), Astroplate-2016 (Prague, Czech Republic) and others (Andruk, 2015a; Muminov, 2016).

Acknowledgements. The authors are thankful to anybody who has read this contribution to the end.

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