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PROGRESS IN THE REALIZATION OF THE PROJECT FON-DUSHANBE CATALOGUE

A.Mullo-Abdolov¹, H.Relke², G.Kokhirova¹, Q.Yuldoshev³, Yu.Protsyuk⁴, V. Andruk⁵

¹Institute of Astrophysics of AS of Republic of Tajikistan, Dushanbe, Tajikistan, aziz.sherzod@gmail.com

²Walter Hohmann Observatory, Essen, Germany, helena_relke@yahoo.com

³Ulugh Beg Astronomical Institute UAS, Tashkent, Uzbekistan, qudratillo@astrin.uz

⁴Research Institute “Mykolaiv Astronomical Observatory”, Mykolaiv, Ukraine, yuri@nao.nikolaev.ua

⁵Main Astronomical Observatory NASU, Kiev, Ukraine, andruk@mao.kiev.ua

ABSTRACT. Since May 2018 the process of the scanning and processing of photographic plates from the archive of the Institute of Astrophysics Academy of Sciences of Tajikistan has begun. It is a matter of approximately 1560 photographic plates in the sky zones from -8 to +90 degrees that were exposed for the FON project in the Hissar observatory (HisAO) during 1985-1992. The plates are digitized by using of the scanner Microtek ScanMaker 1000XL Plus with the resolution of 1200 dpi. The size of the photographic plates is 8°x8° or 30x30 cm, the size of the digitized images is 13000 x 13000 px. So far the first results of the processing of the 71 plates of zero zone and the 58 plates of 64, 68 and 72 zones were obtained. The errors in the definition of equatorial coordinates and B-magnitudes for the stars in the range of 5^m - 17^m are the following: $\sigma_{\alpha\delta} = \pm 0.33''$ and $\sigma_B = \pm 0.12^m$. The differences between the calculated positions and B-magnitudes and the reference one from the Tycho2 catalogue are $\sigma_{\alpha\delta} = \pm 0.12''$ and $\sigma_{BT} = \pm 0.19^m$ respectively. The difference between the calculated and the photoelectric B-magnitudes equals $\sigma_B = \pm 0.15^m$. In the realization of the “FON-Dushanbe catalogue” project five astronomical institutions are involved: Institute of Astrophysics of AS of Republic of Tajikistan; Walter Hohmann Observatory, Essen, Germany; Ulugh Beg Astronomical Institute UAS, Uzbekistan; Research Institute “Mykolaiv Astronomical Observatory”, Ukraine and Main Astronomical Observatory NASU, Ukraine.

Keywords: scanning, processing of digitized plates, FON project, astrometry, photometry, data analysis

АБСТРАКТ. В травні 2018 року за програмою ФОН розпочато процес масового сканування та обробки фотографічних платівок із колекції Інституту астрофізики АН Республіки Таджикистан. За період 1985-1992 рр. в зонах від -8° до +90° експоновано близько 1560 платівок розміром 8° × 8°. Платівки оцифровуються за допомогою сканера Microtek ScanMaker 1000XL Plus, режим сканування — 1200 dpi, розмір платівок – 30x30 см або 13000x13000 px. Отримано перші результати із обробки 71 платівки

нульової зони та 58 платівок 64, 68 і 72 зон. Для фотометричного інтервалу В-зоряних величин від 5^m до 17^m значення похибок визначення екваторіальних координат та В-зоряних величин такі: $\sigma_{\alpha\delta} = 0.33''$ и $\sigma_B = 0.12^m$. Сходимість між обчисленими нами та опорними положеннями із каталогу Tycho2 є такою: $\sigma_{\alpha\delta} = 0.12''$, $\sigma_{BT} = 0.19^m$, а сходимість з фотоелектричними зоряними В-величинами дорівнює $\sigma_B = 0.14^m$. В обробці платівок та створенні каталога ФОН-Душанбе приймають участь п'ять астрономічних закладів: Інститут астрофізики АН Республіки Таджикистан, Обсерваторія ім. Вальтера Хоманна в Ессені (Німеччина), Астрономічний інститут ім. Улугбека АН Республіки Узбекистан, НДІ “Миколаївська астрономічна обсерваторія (Україна) та Головна астрономічна обсерваторія НАН України.

Ключові слова: сканування, обробка оцифрованих платівок, програма ФОН, астрометрія, фотометрія, аналіз даних

1. Introduction

The plan of the photographic survey of the Northern Sky (FON) was proposed in 1976 by the scientists of GAO of USSR G. Kolchinski and A.B. Onegina (Kolchinsky, 1977; Pakuliak, 2016). The idea of the project arose after the acquisition by several observatories of the USSR of identical wide-angle astrographs of the company Karl Zeiss (Jena) with the aperture of 40 cm and the focal lengths of 2 or 3 meters. The project FON was attended by six observatories: Main Astronomical observatory of Ukraine (Goloseevo), Zvenigorod observatory of Russia, Hissar observatory of Tadjikistan, Abastumani observatory of Georgia, Zelenchuk observatory of Russia and Kitab observatory of Uzbekistan. The northern sky should be photographed four times with an overlapping. The Hissar astronomical observatory (HisAO) of the Institute of Astrophysics of AS of Tajikistan also participated in the realisation of the project FON. Regular observations began in 1985 and lasted until 1992. Hamburg O.E., Relke

E.V., Tsygankova M.I., Mullo-Abdolov A. S., Kiselev N.N. took part in the observations. In total, 1578 photographic plates were exposed. The 1560 of which were suitable for the processing. Thanks to the support of the Academy of Sciences of RT the Institute acquired a professional scanner, which allows the scanning of the photoplates with the size of 30 x 30 cm (Mullo-Abdolov, 2017, Rahimi, 2018). In 2017 the scanner was placed on a specially built platform. With the help of the scanner it is planned to digitize the photographic plates exposed for the project FON. The digitized images will be processed with the goal to create a FON-Dushanbe catalogue with exact positions and B-magnitudes of stars, galaxies and other objects. The task is solved together with colleagues from Walter Hohmann Observatory, Essen, Germany; Ulugh Beg Astronomical Institute UAS, Uzbekistan; Research Institute “Mykolaiv Astronomical Observatory”, Ukraine and Main Astronomical Observatory NASU, Ukraine. Earlier, in 2016, within the framework of the UkrVO project (Vavilova, 2012; Vavilova, 2016; Vavilova, 2017) the Kiev part of the program FON was performed (Andruk, 2015b; Andruk, 2016a; Andruk, 2016b) and in 2017 the Kitab part of the project FON was done (Yuldoshev, 2017a; Yuldoshev, 2017b). For the future the creation of the common catalogue of the FON project is planned (Andruk, 2017b). This future FON-catalogue will contain also the U, V values, which will be obtained after processing of digitized photographic plates of 1.2-m telescope in Baldone (Eglitis, 2016; Eglitis, 2017; Eglitis, 2018).

2. First results of processing of the FON-Dushanbe zones

In May 2018 the 71 photographic plates of zero zone and 58 plates of the 64, 68 and 72 zones were digitized and processed. The size of one plate is 8 degrees along the declination and $8\cos\delta$ degrees along the right ascension. So the 90 plates are necessary for the full filling of zero zone with two overlapping. The filling of the sky by the stars of $B = 10^m$ magnitude for zero and near polar zones is showed in the Figure 1 in the form of sky maps. The sequence and principles of the processing of wide-angle digitized plates with the purpose of the obtaining of equatorial coordinates and visual B-magnitudes of registered objects were published in the following works (Andruk, 2015a; Andruk, 2017a).

2.1. Astrometry

Astrometric reduction of the digitized photographic plates with the size of 8×8 degrees is carried out in two steps: the investigation of the systematic errors of the scanner $\Delta\alpha$ and $\Delta\delta$ and then the reduction of rectangular coordinates X, Y of all objects in the system of equatorial coordinates α , δ of Tycho-2 catalogue. At the both steps of data processing the tangential coordinates ξ , η are calculated by the method of the smallest squares using the formula:

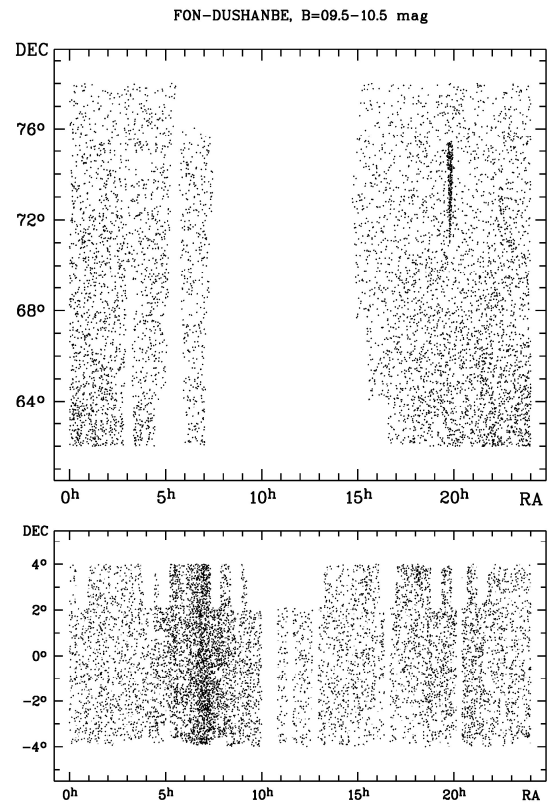


Figure 1: Sky maps. The filling of the sky areas of zero (bottom) and near polar (top) zones of the FON-Dushanbe project with the stars of $B = 10^m$ magnitude

$$\begin{aligned} \xi_i &= a_1 + a_2 X_i f_i + a_3 Y_i f_i + a_4 R_i m_i + a_5 f_i + \sum b_{lm} X_i^l Y_i^m, \\ &\quad (l=0\div 6, m=0\div 6, l+m=n, n=1\div 6) \\ \eta_i &= c_1 + c_2 X_i f_i + c_3 Y_i f_i + c_4 R_i m_i + c_5 f_i + \sum d_{lm} X_i^l Y_i^m, \\ &\quad (l=0\div 6, m=0\div 6, l+m=n, n=1\div 6) \end{aligned}$$

where $i = 1, 2, \dots, N$ – number of stars from the TYCHO-2 catalogue on the digitized plate; X_i , Y_i и R_i – coordinates and distances of star images relative to the center of the plate; m_i – instrumental photometric star values; f_i – diameters of star images; coefficients a_2 , a_3 , a_4 and c_2 , c_3 , c_4 are responsible for the coma; coefficients a_5 , c_5 – take into account the influence of the brightness equation (these coefficients are calculated separately); the b_{lm} и d_{lm} are the coefficients of the full polynomial of degree six (altogether 27 members), which describe in a general case optical aberrations of the telescope complicated by systematic errors of the scanner. The first results of the processing of 58 plates near polar zones and 71 plates of zero zone of the FON-Dushanbe project are show in the Figure 2.

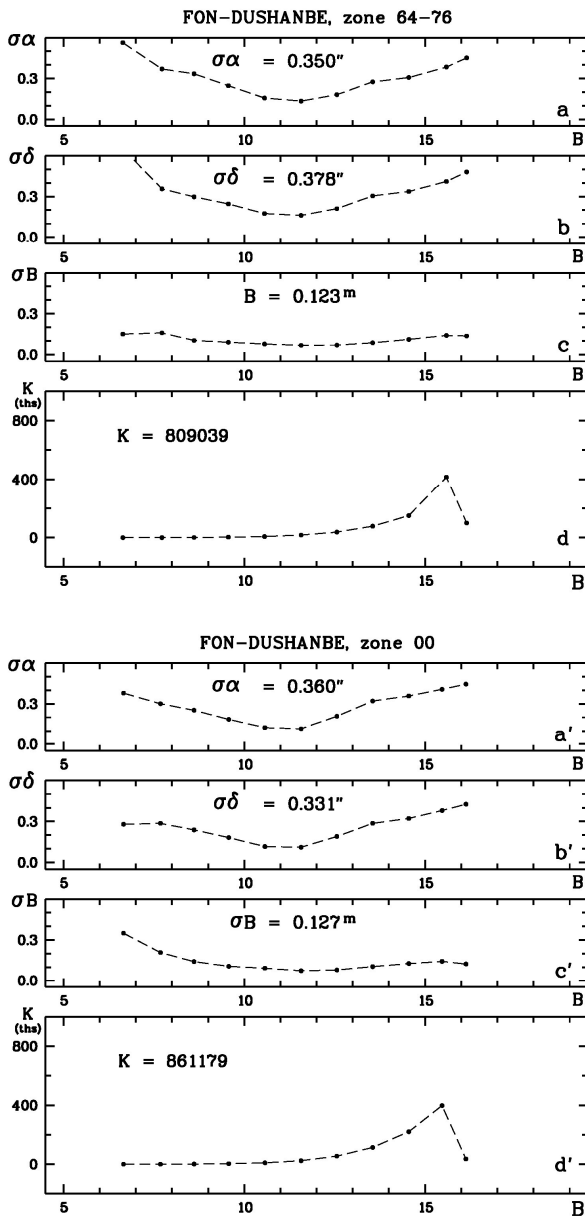


Figure 2: The trend of internal errors for equatorial coordinates and B-magnitudes as well as the number of stars relative to the intervals of the B-magnitudes of the FON-Dushanbe catalogue. The error information for the near polar (64, 68, 72) zones is presented on the upper panels a, b, c and d; for the zero zone - on the lower panels a', b', c' and d'.

The coordinates of the stars and galaxies are obtained in the system of the Tycho-2 catalogue, the B-magnitudes – in the system of photoelectric standards. The mean observation epoch of the FON-Dushanbe catalogue is 1990.5. The values of the internal errors of equatorial coordinates and B-magnitudes of stars and galaxies are equal: $\sigma\alpha\delta = 0.33''$ - $0.36''$ and $\sigma B = 0.13^m$ respectively. The distribution of errors of equatorial coordinates of the FON-Dushanbe catalogue relative to the reference Tycho-2 catalogue for near polar zones and zero zone are presented in the Figure 3.

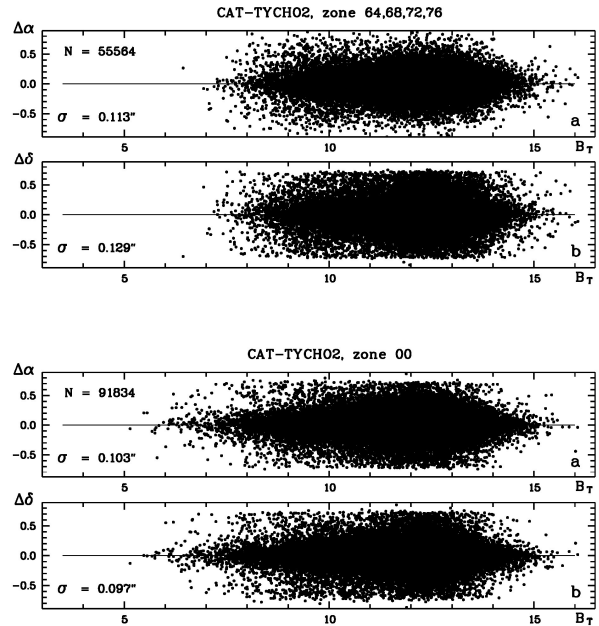


Figure 3: The distribution of mean squared errors of equatorial coordinates of the FON-Dushanbe catalogue relative to the reference Tycho-2 catalogue for the near polar zones (panels a, b) and the zero zone (panels a', b').

2.2. Photometry

The photoelectric B_{pe} values of stars from a specially created catalogue were used as photometric standards for the construction of characteristic curves for each digitized photographic plate (Relke, 2015; Andruk, 2017a). The errors of differences ΔB between the calculated by us B-magnitudes and photoelectric B_{pe} values of stars for more than 2370 stars are equal to $\sigma_B = 0.14^m$. The Figure 4 illustrates the trend of differences ΔB relative to photoelectric values B and B-V.

2.3. Comparison with other catalogues

A separated independent study of astrometric and photometric properties of the zero zone for three catalogues of the FON project (FON-Kiev, FON-Kitab and FON-Dushanbe) were made by special method (Akhmetov, 2016) in the work, which was also presented on the Gamov conference 2018 and was published in the same conference proceeding (Akhmetov, 2018).

3. Conclusion

At the end of June 2018 about 150 photographic plates of zero (00) and polar (64, 68, 72 and 76) zones of the FON-Dushanbe photographic archive were digitized and processed. In parallel these digitized plates are used for the searching of asteroids and comets (Yizhakevych, 2018; Shatokhina, 2017; Shatokhina, 2018). In the Astrophysics Institute of the Academy of Sciences of Tajikistan the work on scanning of plates continues. By the end of 2019 using the results of the processing of all digitized photographic plates (about 1560) it is planned to obtain the FON-Dushanbe catalogue.

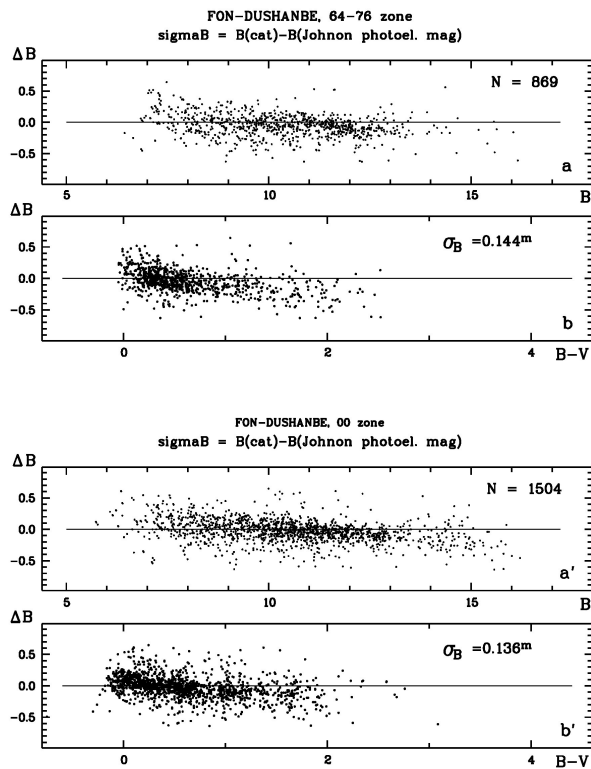


Figure 4: The error distribution of photometry of the FON-Dushanbe catalogue relative to the reference system of the photoelectric B and B-V measurements of stars for the near polar zones (top panels a, b) and zero zone (panels a', b').

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