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# BALDONE 1.2M TELESCOPE PLATE ARCHIVE – HIDDEN RESERVES OF THE FON PROJECT

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ABSTRACT. The plate archive of the 1.2 m Baldone telescope (Latvia) has approximately 780 and 4660 astronegatives exposed in 1967-1993 in the U (ZU21 + UG1 filter plates) and V (A600N + ZS17 filter films) closed to Johnson system U and V passbands. Digitization of astronegatives is carried out using the Epson Expression 10000XL scanner, the scanning mode is 1200 or 2400 dpi, each field covers 19 square degrees of sky. The plates and films are scanned at the Baldone Observatory, processing of digitized scans is carried out by the observers in Baldone, at the Research Institute "Mykolaiv Astronomical Observatory" and at the Main Astronomical Observatory of the National Academy of Sciences of Ukraine. The Epson Expression 10000XL Scanner, along with the software developed, allows us to digitize and process the plates and receive coordinates and magnitudes of registered objects (with high, moderate and low brightness) with an internal error of no worse than 0.05 seconds of arc and 0.03 magnitude. The astrometric and photometric reduction of digitized astronegatives is done in the Tycho-2 reference system and U, V photoelectric system. At this report, we present first results of reduction of more than 2000 astronegatives. Data of U and V magnitudes of stars and galaxies will be used as the photometric addition to the FON project, without, the long-term series of U, V observations have an independent value for studying the variability of stars. Also, many plates included open clusters and will be used for investigation of their population and photometric parallaxes.

**Keywords: s**canning, processing of digitized plates, FON project, astrometry, photometry, data analysis

АБСТРАКТ. Архів склотеки 1.2м телескопу в Балдоне (Латвія) нараховує близько 780 та 4660 астронегативів, експонованих в 1967-1993 роках в U (платівки ZU21 + фільтр UG1) та V (плівки A600N + фільтр ZS17) смугах системи Джонсона. Оцифрування астронегативів здійснюється за допомогою сканера Epson Expression 10000XL, режим сканування — 1200 або 2400 dpi, робоче поле — 19 кв. градусів. Платівки та плівки скануються в обсерваторії Балдоне, обробка оцифрованих сканів здійснюється співробітниками обсерваторії в Балдоне, в НДІ "Миколаївська астрономічна обсерваторія" та в Головній астрономічній обсерваторії НАН України. Планшетний сканер Epson Expression 10000XL разом з розробленим програмним забезпеченням дозволяє оцифровувати і обробляти платівки та отримувати координати та зоряні величини зареєстрованих об'єктів (високої, помірної та слабкої яскравості) з внутрішньою похибкою не гірше 0.05 секунди дуги та 0.03 зоряної величини. Астрометрична та фотометрична редукція оцифрованих астронегативів здійснюється в системі опорного каталога Tycho-2 та U,V фотоелектричних вимірів зір відповідно. В цій роботі ми представляємо перші результати обробки для понад 2000 астронегативів. Дані про U та V величини зір і галактик будуть використані для фотометричного доповнення проекту ФОН, а багаторічні ряди U,V спостережень мають самостійне значення для дослідження змінності зір. Крім того, багато платівок включають розсіяні зоряні скупчення і будуть використані для дослідження їх населення та визначення фотометричних паралаксів.

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

## 1. Introduction

Baldone Observatory of Institute of Astronomy of Latvian University has the photographic collection more than 22000 plates obtained using 1.2 m Schmidt telescope. (Eglite et al, 2016; Eglitis et al,, 2017a). Photographic observation began at the end of 1966 and lasted for 39 years. Each image of Baldone Schmidt telescope covers about 19 square degree of the sky and contains from 10 to 50 thousand images of celestial objects. Scale is 72 "/ mm. As a result, photographic observational archive of Baldone observatory has about 780 U-plates, 5000 B-plates, 4600 V-films and more than 10000 R-plates (Eglitis et al, 2016a; 2016b). Regarding the astronegatives

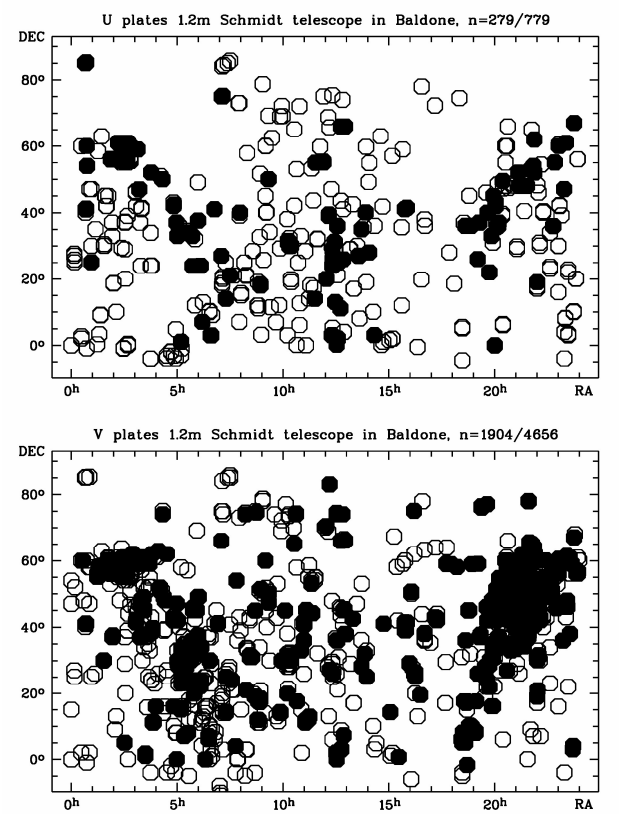


Figure 1: The current state of U and V bands of plate archive digitizing and processing.

exposed in the U (ZU21 plates + UG1 filter) and V (A600N films + ZS17 filters) Johnson system bands, the plate archive, respectively, has about 780 plates and 4660 films, exposed in 1967-1993 (Figure 1). The astronegative U and V collections are scanned on an EPSON EXPRESSION 10000XL scanner with a spatial resolution of 1200 dpi with pixel size near 1.81".

In figure 1 the sections of the starry sky exposed on the 1.2m Schmidt telescope in Baldone in the U (upper part) and V (lower part) bands are presented. Blackened circles correspond to the processed scans of the plates. The astrometric and photometric reduction of digitized astronegatives is done in the Tycho- 2 and U, V photoelectric system respectively. The first results of scan processing show that limit of B and V magnitude on plates with 20 minute exposure is about 19 and 17 magnitude respectively.

Random errors of the scanner for the astronegatives of the Schmidt telescope were investigated in (Eglitis et al., 2017b). Studies have shown that for rectangular coordinates, the errors of one determination of the values of coordinate differences are $\sigma_{xy}$ = 0.021-0.027 px, the errors in the determination of instrumental stellar magnitudes do not exceed the values $\sigma_m = 0.014^m$-$0.016^m$. Considering the scale factor (the value of which is close to two due to the scale and technical characteristics of scanning for astrometry and photoemulsion contrast), the practical errors for the system of equatorial coordinates and U-values will be twice as large. And the following conclusion was made: the Epson Expression 10000XL flatbed scanner together with the developed software allows digitizing and processing the plates and obtaining the characteristics of objects (with high, moderate and low brightness) with an internal error of no worse than 0.05 arc seconds and 0.03 magnitude. For boundary faint objects (U = 16m-17m), our studies gave a result about two times worse. This conclusion concerns scan modes 1200 dpi for astronegatives of 240x240 mm.

## 2. The photometric part of the project FON

The plan for a photographic survey of the northern sky (FON in russian) was proposed in 1976 by the staff of the Main Astronomical Observatory of Academy of Sciences of USSR I.G. Kolchinsky and A.B. Onegina (Kolchinsky, 1977; Pakuliak, 2016). Earlier, in 2016 within the framework of the UkrVO project (Vavilova, 2012; Vavilova, 2016; Vavilova, 2017) implemented the Kiev part of the FON project (Andruk, 2015; Andruk, 2016a; Andruk, 2016b) and in 2017 - the Kitab part of the FON project (Yuldoshev, 2017a; Yuldoshev, 2017b). Data of U and V magnitudes of stars and galaxies from Baldone archive will be used as the useful photometric addition to the FON project.

The photometry of stars and galaxies for the U and V astroplates of the 1.2m telescope in Baldone is made on the basis of the principles implemented in processing the plates of the FON project (Andruk, 2017a) using photoelectric measurements of stars to construct the characteristic curves of plates (Relke, 2015). Future plans include the creation of a consolidated catalogue of the FON project (Andruk, 2017b), including U and V values based on the results of processing digitized plates of the 1.2-m telescope in Baldone (Eglitis, 2016a; Eglitis, 2016b). Regarding the accuracy of processing of digitized U plates, the studies gave the following result. The internal accuracy for all objects is $\sigma_{\alpha\delta}$ = 0.28" and $\sigma_U = 0.20^m$ (for stars in the interval $U = 8^m$ -14 $^m$, the errors are $\sigma_{\alpha\delta}$ = 0.11" and $\sigma_U$ = 0.09m) for equatorial coordinates and star magnitudes, respectively. The convergence of the coordinates with the Tycho-2 reference system is $\sigma_{\alpha\delta}$ = 0.06". The convergence with photoelectric stellar $U_{pe}$ values is $\sigma_B = 0.13^m$. The results of processing photographic observations of the 1.2 m telescope in Baldone can be used to improve the photometric parameters of the summary FON catalogue, to study variable stars and open clusters. The coordinate part in the U band can also be used to refine the proper motions of stars. To use the coordinate part in the V band, it is necessary to carry out studies of films deformation during scanning and improve processing techniques.

## 3. Conclusion

Baldone Schmidt archive in some area of sky contain 20 – 30 years regular observations, that will be a good source for investigation of variable stars of different type and for detection of proper motion of stars.

The traditional field of research in Baldone observatory is an investigation of carbon stars. Some of this late objects are situated close to clusters. One of the unclear characteristics of C stars in the Milky Way galaxy is their absolute magnitude. Therefore Baldone archive contains

multicolour wide-field observations of open clusters which are near carbon stars. These digitized plates will be an exclusive source for investigation of their population and photometric parallaxes.

At present, according to the accepted methodology (as part of the FON project), more than two thousand astronegatives exposed at the 1.2 m Schmidt telescope in Baldone in the U and V bands are being processed. The coordinates of stars and galaxies are reduced to the Tycho-2 catalogue system, U and V values to the photoelectric standards system. Work on the processing of astronegatives continues.

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