ASTEROID SEARCH RESULTS FOR DIGITIZED ASTROPLATES OF 1.2m TELESCOPE IN BALDONE

1. Introduction

The purpose of this work is to search for images of small bodies of the Solar System from digitized plates of clusters observations in 1967-1993 at the astronomical observatory in Baldone. Determining the coordinates and compiling a catalog of asteroid positions are the main tasks of this work.

In 1965, a Schmidt SmA camera was installed in Baldone on the territory of the Astronomical Observatory of...
the Institute of Astronomy of the University of Latvia with the following parameters: diameter of the mirror - 120 cm, diameter of the correction plate - 80 cm, focal length - 240 cm, field of view 446' x 446' min. The first effective observations were obtained in December 1966.

Over 40 years of photographic observations on various programs, the Baldone’s collection of astronegatives including more than 22,000 direct images in a wide range of exposures. Among them there are approximately 780 photographic plates in U spectral band exposed with a UG1 filter, 4600 films in V band exposed with a ZS17 filter (Eglitis et al., 2016a).

From 2013 the regular digitization and processing of photographic astroplates started in Baldone observatory. The plates were digitized using Epson Expression 10000XL and 11000XL commercial scanners with the resolution 1200 dpi. The further software for scan processing was developed and implemented in MAO NASU to process the digitized astronomical negative plates as well as to obtain the final product in the form of a catalogue of positions and stellar magnitudes for all registered objects on the plate. For detail the techniques of astroplate digitization and further processing and determination of coordinates and magnitudes of stars are described in the series of publications (Andruk et al., 2016a; 2016b; Protsyuk et al., 2014). The special modernized programs were developed at MAO NASU for constructing individual characteristic curves and determining stellar U, V values with a single exposure (Andruk et al., 2019).

The equatorial coordinates α, δ and stellar magnitudes of all objects on the plates were obtained in the reference system of Tycho-2 at the epoch of exposition of each plate. The magnitudes of all objects are obtained in the system of photoelectric standards.

2. Results

The processing results (Eglitis et al., 2016a; 2017; 2018) of digitized photographic observations of star clusters in UBVR bands at the Baldone observatory during 1967-1996 were used for a global search for small bodies of the Solar system. An online internet service from JPL was used for this (https://ssd.jpl.nasa.gov/sbfind). The first stage of this search was begun in 2016. As a result 87 images of minor planets from 9.8 to 17.1 stellar magnitude and 2 images of comets were identified on 152 plates (Eglitis et al., 2016b). Now we continued this work and carried out the search for asteroids based on the results of processing the remaining plates observed in U, V bands. A total of 272 plates were used in the U band and more than 1,400 films in the V band. Asteroids and comets were detected on 107 plates (361 positions) in U band and 223 films (1401 positions) in V band. Their positions were compiled into a preliminary catalog.

In addition, in vicinity of each position of the asteroid, stars from the Gaia DR2 catalog were selected to determine the possible coverage of the images of stars with an image of the asteroid on the plate. In these cases, the coordinates or magnitudes of the asteroid are determined ambiguously on the plate. Such asteroid positions were excluded from the compiled catalog.

The quantitative distribution of all used photographic observations over the years compared to the number of effective observations for the search for asteroids is presented in Fig. 1 and Fig. 2.

As a result of reduction processing with the reference catalog of Tycho-2, the root-mean-square (RMS) errors σ of determining the coordinates of stars on the plates were obtained. For U-plates, the internal accuracy of determining the coordinates of stars is approximately in the range of 0.05-0.53 arc seconds. For V-films, the range of RMS errors is much wider, especially for right ascension, when these values reach 1.8 arc seconds. This may be due to the uneven curvature of the film surface during scanning (Table 1).

![Figure 1: Distribution on time scale of all observations in V band in Baldone observatory.](image1)

![Figure 2: Distribution on time scale of all observations in U band in Baldone observatory.](image2)

### Table 1: Ranges of root-mean-square errors of determining the coordinates of stars for U and V plates.

|             | 107 U-plates | 223 V-films |
|-------------|--------------|-------------|
| σ_{RAcat}, arcsec | 0.05-0.53    | 0.06-0.63   |
| σ_{Deccat}, arcsec | 0.34-0.39   | 0.63-0.53   |
| σ_{U}, mag     | 0.01-1.76    | 0.12-0.53   |
long-term sets of photographic observations made in previous years can become the basis not only for creating catalogs of coordinates of stars and galaxies but also for determining precise positions of small bodies of the Solar system. Using the digitized photographic plates of the archives of the Baldone Observatory, we can identify faint moving objects up to 18\textsuperscript{m} and determine their coordinates and magnitudes with high accuracy. Among those may be objects which were discovered much later than were fixed on those astronegratives, and unique asteroids and comets including selected trans-Neptunian distant objects.

Using data about precise positions and magnitudes of asteroids, some tasks of refining ephemeris, studying changes in asteroid orbits over time, non-gravitational effects in the evolution of asteroid’s orbits, constructing light curves and phase dependencies can be solved.

Cooperation with Ukrainian Virtual Observatory (UkrVO) gives the opportunity to expand this work, involving numerous additional files of digitized observations and different services and software for modern processing of observation and, ultimately, to increase the number of new original data about Universe.

Intensive work on the creation of catalogs of stars and galaxies and small bodies of the Solar system based on digitized photographic observations of star clusters of archives in Baldone was successfully carried out with the active support of UkrVO [Vavilova et al., 2016; 2017].

The main results of such studies have been previously reported at different conferences.

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