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THE PLATE ARCHIVE OF THE STERNBERG ASTRONOMICAL INSTITUTE

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Abstract. We present information on the contents of the Sternberg Astronomical Institute's plate archive that contains sky photographs acquired during more than a century, on the efforts aimed at digitizing this archive, and on the prospects of its use for solar-system studies.

HISTORY OF THE STERNBERG ASTRONOMICAL INSTITUTE'S PLATE ARCHIVE

First attempts to use techniques of astronomical photography at Moscow Observatory were undertaken as early as in 1883. The famous Russian astronomer and astrophysicist, A.A. Belopolsky (1854–1934), worked in Moscow before his move to St. Petersburg in 1888. He tried to use the collodion wet plate process to take photographs of starry sky with a small telescope. About 10 of his plates survived; the quality of these photographs is very low.

Systematic photographic observations in Moscow Observatory (after 1931, the Sternberg Astronomical Institute, SAI) started in 1895. The initiator was another famous Russian astronomer, S.N. Blazhko (1870–1956). At that time, observations were performed with a small camera ($D = 10$ cm, $F = 64$ cm) at the Presnya site, only about 6 km from the very center of the city. Plates from this camera, 24 cm×30 cm in size, cover $20° \times 28°$ of the sky, to a limiting magnitude about 13–14. The camera had very strong aberrations towards plate edges. It was in use till 1933, a total of 1100 plates were taken. It should be noted that the old collection is kept well, most plates are in excellent shape.

Starting with 1902, other cameras, some of them considerably larger, were introduced. Currently, the SAI collection contains sky photographs obtained with seven different instruments at no less than 6 observing sites in Moscow (2 sites), Crimea, Uzbekistan. In total, more than 60 000 photographic plates have been accumulated by 2004.

Among plates taken for studies of variable stars, the most important part of the plate collection are 22 300 photographs taken in 1948–1996 with the astrograph ($D = 40$ cm, $F = 160$ cm) built in 1930s for Sonneberg Observatory (Germany). In Sonneberg, this telescope was known as the GA astrograph; a rather large number of plates taken with it are kept in Germany. In 1945, the astrograph became a part of war reparations. First installed in Simeiz (Crimea), it was then moved to Kuchino near Moscow and then returned to Crimea, to a site in Nauchny, were it was in use after May 1958. These sky

photographs, on glass plates 30 cm×30 cm in size, correspond to $10^\circ \times 10^\circ$ of the sky. The limiting magnitude was initially about $17.5^m B$, but later somewhat deteriorated, mainly because of light pollution in Crimea.

About 10 000 plates were taken in Moscow Observatory for astrometric purposes. We call them as astrometric plates. Most of these plates were obtained in the following programs: measuring astrometric positions of 15 selected asteroids in order to refine the equinox of fundamental star catalogs (Brouwer, 1935; Eliseev, 1988; Vozdvizhenskii et al., 2012); measuring coordinates of Venus (Vozdvizhensky, 2010), Mars (Vozdvizhenskij, 1994), and Pluto (Dolganova et al., 1993), to improve theories of planetary motion; compilation of a special star catalog along the track of Comet Halley (Evstigneeva, Shokin, 1988); measuring absolute proper motion of stars with respect to galaxies in selected areas of the sky. Almost all the plates were obtained with an astrograph ($D = 23$ cm, $F = 230$ cm), the field of view being $6^\circ \times 6^\circ$ on 24×24-cm. plates. The astrograph has Ross-type lenses manufactured in Leningrad (now St. Petersburg) in 1955 and a very good image quality over the entire field (Bochkarev et al., 1979). Plate emulsions types were ORWO ZU1, ZU2, ZU21. Before 1988, the astrograph was installed near the Moscow University. In 1988, it was moved to Mt. Maidanak (Uzbekistan). The limiting magnitude in Moscow was first about 17^m and deteriorated to 14^m with the development of street lighting. The accuracy of positional measurement for stars was about 0.2 arcseconds. This is limited by the accuracy of a manual meter. Most of our plates were photographed with an exposure time of 15 minutes, giving the limiting magnitude about 12^m, but there were also exposure times from 40 minutes to 1 hour, with the limiting magnitude of $16^m - 17^m$. The original purpose of these observations is not relevant now, but old accurate observations may contribute to the refinement of the dynamic and kinematic coordinate system relative orientation (Chernetenko, 2008).

Plates of the Sternberg Institute archive were used by many researchers, numerous scientific papers were published.

In the Moscow Region, there also exists a sky-photograph archive of Zvenigorod Observatory (Samus et al., 2006); it is not discussed here. Its digitization has been recently completed.

CURRENT WORK

Plate logs of the Moscow archive are kept as paper documents at the corresponding departments of the Sternberg Institute. They differ in their data format. During the recent years, they were partly typed as electronic documents. In particular, there exist complete electronic logs of plates from the 40-cm astrograph (1948–1996) and of two old series of plates (1895–1956, 3800 plates).

Logbooks of plates taken for studies of variable stars usually did not contain coordinates of the plate center; instead, the name of the central object was indicated. In the first half of 2012, all electronic logbooks mentioned above were appended with approximate J2000.0 coordinates of plate centers (the photographs being wide-field, very high accuracy of center coordinates is not needed).

Log data for 10 000 astrometric plates are currently available in electronic form.

Since 2004, work on digitizing the variable-star part of the plate collection started (Samus et al., 2006). It made use of two Creo EverSmart Supreme scanners, used at

resolution of 2540 dpi. This resolution permits to keep information for all stars actually visible in a photograph, including the faintest ones. About 1700 scans of the old collection and the 40-cm-astrograph collection have been digitized. Already available scans are used to search for variable stars using semi-automatic techniques; more than 500 variable stars have been thus discovered so far (cf. Kolesnikova et al., 2010). Unfortunately, by 2011, both scanners need reparation, and attempts to do it have not been successful so far. Purchasing new scanners is being currently planned. Also, studies of the astrometric properties of the scans revealed complex periodic mistakes of rectangular coordinates that do not exactly reproduce themselves from one scan to another, making astrometric use of the scans problematic. To now we do not have a scanner that would permit to achieve quality of linear measurements better than 0.002 mm.

PROSPECTS FOR ASTROMETRY AND PLANETARY STUDIES

The plates taken for astrometric purposes (see above) may be subject to new processing with new star catalogs after they are scanned. This work can be undertaken if there is interest in new modest-accuracy astrometric data for Mars, Venus, and selected asteroids. The positional accuracy expected for these plates is about 0.2 arcseconds.

In 2012, we have initiated work to search for objects of the solar system in the photographic plates taken for studies of variable stars and galaxies. The main interest is to find planets with natural satellites. Time of mid-exposure and coordinates of the field center known, we use existing software to check for the presence of planets in each plate. For this purpose, it is important to have coordinates of plate centers written in the electronic logbook (see the previous section); there still remain thousands of Moscow-collection plates with this information available only in the form of paper notes. Of approximately 25 000 plates with sufficient data available electronically, it was found that planets are present only on 340 of them. If specially measured astrometrically, these plates will provide accuracy not better than 1 arcsecond; however, such measurements can be of interest in the case of old plates with satellites of planets visible.

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