THE SCIENTIFIC USE OF THE UKRVO JOINT DIGITAL ARCHIVE: GRBs FIELDS, PLUTO, AND SATELLITES OF OUTER PLANETS

I. Vavilova [1], V. Golovnya [1], V. Andruk [1], L. Pakuliak[1], O. Yizhakevych[1], S. Shatokhina[1], Yu. Protsyuk[2], L. Kazantseva[3], V. Lukianchuk[1,4]

[1] Main Astronomical Observatory NAS of Ukraine, Kyiv, Ukraine, *golov@mao.kiev.ua, andruk@mao.kiev.ua*,
[2] Nikolaev Astronomical Observatory, Mykolaiv, Ukraine,
[3] Astronomical Observatory, Kyiv Shevchenko National University, Ukraine,
[4] Kyiv Shevchenko National University, Ukraine

ABSTRACT. In the framework of UkrVO national project the new methods of plate digital image processing are developed. The photographic material of the UkrVO Joint Digital Archive (JDA – http://gua.db.ukr-vo.org/vomao/DB/archivespecial.php) is used for the solution of classic ast-rometric problem – positional and photometric determinations of objects registered on the plates. The results of tested methods show that the positional rms errors are better than ±150 mas for both coordinates and photometric ones are better than $\pm 0.20^{m}$ with the Tycho-2 catalogue as reference.

Key words: virtual observatory, GRB, small Solar system bodies

1. Introduction

The national project of the Ukrainian Virtual Observatory (UkrVO) has breathed new life into the old observational archives. The Joint Digital Archive (JDA) of photographic observations has become the core of the UkrVO. JDA, which includes observational archives of five Ukrainian observatories and covers the observational period of around 100 years (http://gua.db.ukr-vo.org/archivespecial.php) [1–4]. The great part of JDA (about 70%) embraces archives of two Kyiv observatories: MAO NAS of Ukraine and AO of Kyiv national university. In the UkrVO framework, the digitizing of glass collections is conducted. At present, JDA controls 50 Kyiv observational archives with 40,000 metadata records and near 14,000 digital images. The JDA is supplemented by 14,500 digital images of observational logging records, identified with 23,000 photographic plates, included into the database, as well as about 6,000 arrays of coordinates and photometric data of objects, registered on the plates and derived in preprocessing procedures.

In addition to the direct images the photographic archive of MAO NASU contains about 50,000 photographic plates with spectra. This archive includes the material of a large number of observational projects and can be partly classified and digitized. We started the process of digitizing some collections of spectra, which are well documented and can be included into the spectral library (UkrVO SDL, http://ukr-vo.org/spectra).

Another form of archives representation is a standard format accepted for the Wide-Field Plate Database (WFPDB), which represents the largest archives of the world astronomical observatories. Catalogs have been transformed to this format and integrated to WFPDB (www.skyarchive.org) [5].

2. Astrometric solutions with the JDA

Plate digitizing is carried out using a flatbed scanner Epson Expression 10000XL with 16-bit gray levels, resolution of 1200 dpi. Digitized images are stored in TIFF and FITS formats. The results of digitizing are used for decision of the following scientific tasks: enrichment of FONAK astrometric catalogue (the photographic review of the northern sky) with data of objects, registered on the digitized images down to 16^{m} (B band) [6]; search of optical analogue of GRB and creation of catalogues of objects in the areas around GRBs; creation of astrometric catalogues of coordinates of Pluto and outer faint satellites of Jupiter and Saturn; elaboration of proper methods of treatment and obtaining astrometric coordinates for asteroids and comets [7]. The astrometric and photometric calibration procedures were developed on the basis of LINUX-MIDAS-ROMAFOT software [8, 9]. The improvements concern to the topocentric coordinates, their correction for scanner instrumental errors, the specific form of object image and application of different models for the final reduction in the Tycho-2 frame as reference. The comparison of obtained positions with ephemerides was made using IMCCE (Paris) [10].

2.1. The catalogs of objects in the areas around GRBs

The results of continuous GRB observations onboard spacecrafts are published in GCN Circulars and handed over to observatories for investigation of any objects in the sky areas around the GRB. The last task in addition can be solved using the JDA data. Objects, which potentially could appear on the archive plates, were selected in GCN Circulars published data. The positional accuracy of selected objects is between ±0.3″ and ±7.0″ and the range of magnitudes is 14^{m}–19^{m}. GRBs and all the objects are sought and identified on the digitized plates within the circle with the radius of dozens of arc minutes. Up to date the analysis of coordinates for 108 GRBs, taken place in 2003, 2009–2013, has been carried out. The bright objects with coordinates different from those of given to GRB but absent in vast stellar catalogues, were found in several

areas. Study of these objects is going on with attraction of other observational facilities [11]. The data of 26 areas are published in GCN Circulars [12–26]. Faint objects were found in the vicinity of two non-identified GRBs by the program of their positional data. We obtain catalogues of stars in the vicinity of GRB110213A (4′x4′), GRB101224A (10′x10′) and GRB090113 (8′x8′).

The work is in process. Catalogues are available on the web site of MAO NASU and UkrVO.

2.2. Astrometric solutions for Jupiter and Saturn satellites

The UkrVO JDA contains considerable observational material (more than 300 plates) on the main satellites of Saturn (S1–S8) and the outer satellites of Jupiter (J6–J8) obtained by four telescopes (DDA, DSHA, DAZ, TS600) during 1961–1993 [1–4]. In 1990 the reduction was carried out and partially published [27, 28]. At that time the measurement of negatives were realized using Askorekord and PARSEK instruments. Reference systems served the catalogues AGK3, PPM, CMC. At present, we start to reprocess all the observations using the scan processing method described in [8, 9]. As the reference frame the catalogue Tycho2 system was chosen. It has been already processed about 40% of the observational material. Simultaneously we carry out the comparison with the ephemeris [10] online. Standard error of deviation from the theory is about 0.20″–0.35″ in both coordinates. The work is in process too.

2.3. Catalogues of Pluto astrometric data

The JDA archives contains 77 digital images of plates with Pluto related to 1961–1990 years of observations. The main goals of their treatment were to determine whether the better positional accuracy could be achieved with those photographic material due to new methods of image processing and could the scanned images in general be used for the astrometric solutions with a high positional accuracy in applications for moving objects. Using the current results we obtain the joint catalog of Pluto positions. The part of plate sets was earlier used for positional determinations and the compilation of the Pluto positional catalogue. For current data rms errors of unit weight are 2 to 3 times better than that of classic methods [29– 31].

The comparison of results [31] for plates of different linear dimensions (13x13 cm to 30x30 cm), scales (38″ to 103″/mm) and expositions (5 to 60 minutes) permits to obtain the reliable material concerning the regularity of (O-C) in the system of planet coordinates in relation to appropriate values of different ephemerides in the specified time period. Digital images of plates and state-of-art stellar catalogues allow to improve the accuracy of positional determinations, using the earlier unusable photographic material for the enhancement of observational series with reliable results, and to involve more faint stars omitted previously into the processing of plates.

Conclusion

Our results suggest that the old observational archives, which are presented on the astroplates, can generate new knowledge in addition to current projects and new methods of observations [32–35]. One can register your archives on the WIKI [36].

References

1. Vavilova I.B. et al.: 2012, Kinematics and Physics of Celestial Bodies, **28**, 85.
2. Vavilova I.B. et al.: 2012, Baltic Astronomy, 21, 356.
3. Pakuliak L. et al: 2013, Odessa Astron. Publ., **26/2**, 236.
4. Vavilova I.B. et al.: 2010, *Kosmichna Nauka i Tekhnologiya*, **16**, 62.
5. Tsvetkov M.K. et al.: 1995, *Lect. Not. in Phys.*, **454**, Flares and Flashes, IAU Colloquium 151, Eds. J. Greiner, H.W. Duerbeck, R.E. Gershberg, Springer Verlag, p. 412.
6. Andruk V. et al: 2005, *Kinematika i Fizika Nebesnykh Tel*, **21, N5**, 396.
7. Golovnya V., Andruk V.: 2013, Odessa Astron. Publ., **26/2**, 226.
8. Andruk V.M. et al: 2010, *Kinematics and Physics of Celestial Bodies*, **26, N3**, 146.
9. Golovnya V. et al: 2010, *J. Phys. Studies*, **14**, 2902.
10. Natural Satellites Ephemeride (IMCCE.Paris) http://www.imcce.fr/hosted_sites/saimirror/nssephe.php
11. Golovnya V. et al: 2012, *Kyiv Univ. Messenger. Astronomy*, **49**, 36 (in Ukrainian).
12. Golovnya V.V.: 2011, *GCN Circul. Archive*, 12113.
13. Golovnya V.V.: 2011, *GCN Circul. Archive*, 12306.
14. Golovnya V.V., Kizyun L.N.: 2011, *GCN Circul. Archive*, 12586.
15. Golovnya V.V.: 2011, *GCN Circul. Archive*, 12680.
16. Golovnya V.V.: 2011, *GCN Circul. Archive*, 12786.
17. Golovnya V.V.: 2012, *GCN Circul. Archive*, 12807.
18. Golovnya V.V., Kizyun L.N., Pakuliak L.K.: 2012, *GCN Circulars Archive*, 12808.
19. Golovnya V.V.: 2012, *GCN Circul. Archive*, 12827.
20. Golovnya V.V.: 2012, *GCN Circul. Archive*, 12875.
21. Golovnya V.V.: 2012, *GCN Circul. Archive*, 12906.
22. Golovnya V.V.: 2012, *GCN Circul. Archive*, 12918.
23. Golovnya V.V.: 2012, *GCN Circul. Archive*, 13014.
24. Golovnya V.V.: 2012, *GCN Circul. Archive*, 13066.
25. Golovnya V., Yatsenko A., Pakuliak L.: 2012, *GCN Circul. Archive*, 13086.
26. Golovnya V.V.: 2014, *GCN Circul. Archive*, 16650.
27. Izhakevich E.M., Pakuliak L.K., Kulyk I.V.: 2012, *Proc. of the Conf. NAROO-GAIA, June 20- 22, 2012, France, Paris,* p. XX.
28. Izhakevich, E.M. et al.: 1994, *Kinematics and Physics of Celestial Bodies*, **10**, 88.
29. Shatokhina S., Yizhakevych O.: 2005, *Kinematika i Fizika Nebesnykh Tel*, Suppl, **5**, 570.
30. Telnyuk-Adamchuk V., Pasechnik S.: 1989, *Kyiv Univ. Messenger. Astronomy*, **31**, 82.
31. Shatokhina S. et al.: 2015, *Kinematics and Physics of Celestial Bodies*, **31** (accepted).
32. Golovnya V. et al.: www.astroplate.cz/wp-content/uploads/2014/01/Golovnya_UkrVO_new_life.pdf
33. Vavilova I. et al.: www.astroplate.cz/wp-content/uploads/2014/01/Prague-UkrVO-Vavilova-et-al.pdf
34. Protsyuk Yu. et al.: www.astroplate.cz/wp-content/uploads/2014/01/Protsyuk-NAO_2014-a.pdf
35. Vavilova I.B. et al.: 2011, *Kosmichna Nauka i Tekhnologiya*, **17**, 74.
36. Tuvikene T. et al.: www.plate-archive.org/wiki/index.php/Main_Page.