DATA PROCESSING OF PLATES CONTAINING IMAGES OF URANUS AND NEPTUNE FROM UKRVO DIGITAL ARCHIVE: STRUCTURE, QUALITY ANALYSIS

Protsyuk Yu.[1], Yizhakevych O.[2], Kovylianska O.[1] , Protsyuk S.[1], Andruk V.[2], Kashuba S.[3], Kazantseva L.[4]

[1] Research Insitute: Nikolaev Astronomical Observatory, Ukraine, *yuri@nao.nikolaev.ua*
[2] Main Astronomical Observatory, National Academy of Sciences, Ukraine, *andruk@mao.kiev.ua*
[3] Astronomical Observatory, Odessa National University, Ukraine, *sv.kashuba@gmail.com*
[4] Astronomical Observatory, Kyiv National University named after T. Shevchenko, Ukraine, *kazl@ukr.net*

ABSTRACT. To use accumulated resources of UkrVO digital archive, analysis of the available photographic plates containing images of Uranus and Neptune was conducted. Data processing of selected plates was also caried out to provide an estimate of positional precision and accuracy. Archives of the Research Institute: Nikolaev Astronomical Observatory (NAO), Main Astronomical Observatory of National Academy of Science (MAO), Astronomical Observatory of Odessa National University (AO ONU), Astronomical Observatory of Kyiv National University (AO KNU) were used. Numbers of plates containing images of Uranus and Neptune are, respectively, the following: 220 and 218 plates in NAO, 64 and 35 plates in MAO, 54 and 44 plates in AO ONU, 3 and 1 in AO KNU. Plates of NAO and MAO have 2 or 3 exposures per plate, and other plates have only one exposure per plate. The epoch of observation for most plates is 1960 to 1998, and for only one plate is 1908.

All plates were scanned with the resolution not less than 1200 dpi. Each plate of NAO was scanned 5 to 6 times. Plates containing images of Uranus and Neptune were, respectively, scanned 618 and 952 times in NAO. All plates of other observatories were scanned only once. Raw image processing for scans containing images of Uranus and Neptune was conducted for all scans obtained in observatories. (X, Y) coordinates, (I) intensities and FWHM values were obtained for images of all objects.

Star identification for scans containing images of Uranus and Neptune was, respectively, conducted for 600 and 936 scans in NAO and for 71 scans in MAO. Coordinates of all objects were obtained. Positional accuracy of reference stars was estimated for 244 plates of NAO and 66 plates of MAO, and has value of 0.08″-0.26″.

Keywords: astronomical data bases – astrometry – methods: data analysis – catalogs

1. Introduction

In 2014 we used Joint Digital Archive (JDA) database of UkrVO (Vavilova et al., 2012a, 2012b) to find and recalculate all Ukrainian observations of Pluto (Kazantseva et al., 2015). In 2015 we continue this work and analysis of the available photographic plates in JDA, containing images of Uranus and Neptune, was conducted.

Archives of the NAO (Zonal Astrograph (ZA, D/F=12/204, 101"/mm), MAO (Double Wide-angle Astrograph (DWA, D/F = 40/200, 103"/mm), Double Long Focus Astrograph (DLFA, D/F=40/550, 37"/mm)), AO ONU (Seven Wide Angle Astrograph (SWA, D/F=12/60, 313"/ mm)) and AO KNU were used. Then, we start scanning of this plates and make processing of a received images. Using different kind of software we obtained coordinate of the planets and comparing results with well known ephemerides.

2. Structure of archive and plate scanning

We found more than 600 plates with Uranus and Neptune in UkrVO. Structure of plate archives is shown in Table 1.

Table 1. Structure of plate archives

	Telescope, epoch	Uranus, plates	Neptune, plates
NAO	ZA 1961-1998	220	218
MAO	DLFA, DWA, Z600 1963-1991	64	35
AO ONU	SWA 1960-1989	42+12	32+12
AO KNU	AZT8, DAMR 1988, 1908	3	1

All plates in NAO and MAO have 2 or 3 exposures per plate. Another one have only one exposure. 12 plates of AO ONU have Uranus and Neptun in same plate.

After searching in JDA all plates were scanned with the resolution not less than 1200 dpi (part of plates in NAO were scanned with the resolution 1600 dpi). Current status of the scanning shows in Table 2.

Table 2. The current status of the plate scanning

	Uranus, plates	scaned, plates/scans	Neptune, plates	scaned, plates/scans
NAO	220	104/618	218	160/952
MAO	64	39/39	35	35/45
AO ONU	42+12	48/54	32+12	38/38
AO KNU	3	3/3	1	1/1

Each plate of NAO was scanned 5 to 6 times without turning. Plates containing images of Uranus and Neptune were, respectively, scanned 618 and 952 times in NAO. All plates of other observatories were scanned only once (ecsept one plate of MAO and AO ONU with 6 scans for testing purpose).

3. Data reduction and quality analysis

For raw image processing we used MIDAS/ROMAFOT software (Andruk et al., 2010; Protsyuk et al., 2014a, 2014b). Raw image processing for scans containing images of Uranus and Neptune was, respectively, conducted for 618 and 952 scans in NAO and for all scans obtained in other observatories. (X, Y) coordinates, (I) intensities and FWHM values were obtained for images of all objects. The current status of raw image processing shows in third column of Table 3 (considering that 1 plate in NAO usually have 6 scans).

Table 3. The current status of the raw image processing and identification

	scaned, plates	processed in MIDAS, plates	identified, plates	no identified, plates
RI NAO	264	264	244	8
MAO	74	74	66	8
AO ONU	86	85	2	-
AO KNU	4	4	1	-

For star identification we used two different software package for LINUX and WINDOWS system (Protsyuk et al., 2014; Andruk et al., 2016). Star identification for scans containing images of Uranus and Neptune was, respectively, conducted for 600 and 936 scans in NAO and for 71 scans in MAO. Some of plates no identified due to quality of images and errors in observation. After identification coordinates of all objects on plates were obtained in Tycho-2 system (Protsyuk et al., 2014; Andruk et al., 2016). Positional accuracy of reference stars shows in Table 4. In first column scale of one pixel in seconds of arc specified. In columns from 4 to 6 standart deviation (SD) of planet's position (in arcsec and pixel) and magnitude shows. Table 4 shows, that SD of planet's position is in ranges 0.10-0.12 pixel in main part of archive, that corresponds depending on the scale from 0."08 to 0."26. Plates of AO ONU have large scale and big distortion near the border, so, errors in seconds of arc also big.

Table 4. The current status of the reduction

	Proc., plates	Ident., plates	SD of planet RA position, arcsec|pix	SD of planet DEC pos., arcsec|pix	SD of mag
NAO 2.1|1.6	264	244	0.19|0.11	0.19|0.11	0.01-0.07
MAO DLFA 0.8	74	66	0.09|0.11	0.08|0.10	0.01-0.03
MAO DWA 2.2			0.22|0.10	0.26|0.12	0.04-0.05
AO ONU 16.9	85	2	2.2|0.13	2.7|0.16	0.01-0.03
AO KNU	4	1	-	-	

Since the NAO has a 6 scans for each plate we obtained inner accuracy of planets coordinate. Distribution of quantity of SD of positions in seconds of arc shows on Fig. 1 for Uranus and on Fig. 2 for Neptune.

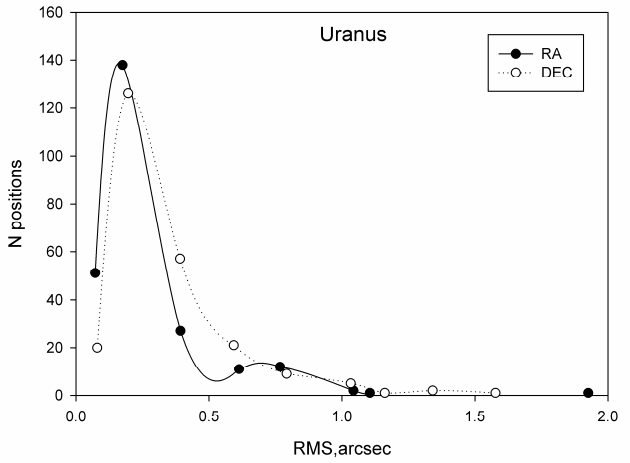

Figure 1: Distribution of quantity of SD of Uranus position in seconds of arc

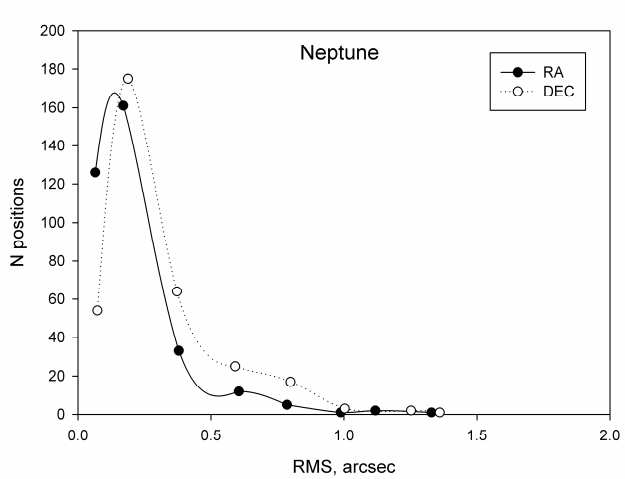

Figure 2: Distribution of quantity of SD of Neptune position in seconds of arc

Some plates of NAO have 5 exposures, so, we obtained track of planet position during time of observation (Fig. 3, Fig. 4).

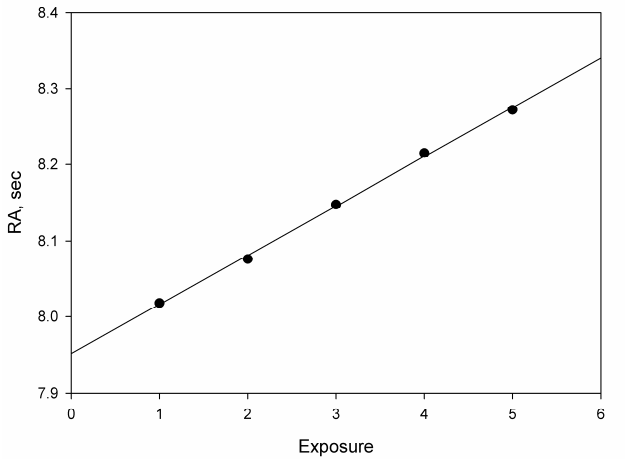

Figure 3: Track of the Uranus in RA direction on one of a plates

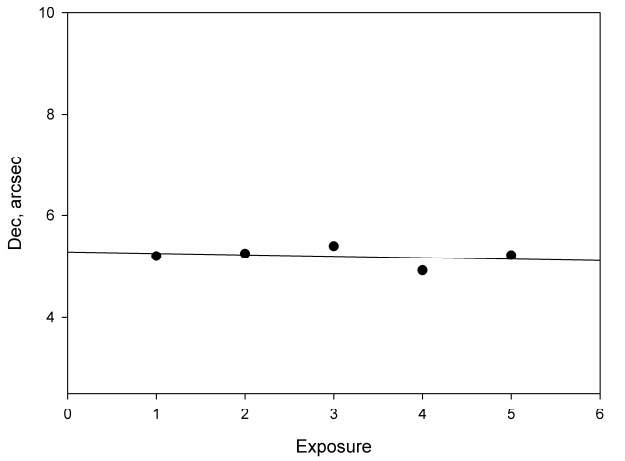

Figure 4: Track of the Uranus in DEC direction on one of a plates

For all moments of planet's observation we downloaded planet's position from The Institut de Mecanique Celeste et de Calcul des Ephemerides (IMCCE) ephemeris web-site and were compared our results with well known ephemerides.

4. Conclusion

We were found in UkrVO archive 627 plates with 1701 exposures of the Uranus and Neptune. Were scanned and processed in MIDAS software 428 plates on date. And were identified 313 plates with 932 positions of Uranus and Neptune. Obtained positions were compared with known orbital theories and were received (O-C) for them.

For next period we will modify program for processing AO ONU observations, finishing scan, reduction and identification of all UkrVO plates with Uranus and Neptune. Also we shall include satellites of the planets in workset and using of those coordinates for improvement of the orbital theory of the planets and their satellites.

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