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## THE FIRST RESULTS OF PROCESSING OBSERVATIONS OF SS BODIES FROM UBAI PHOTOGRAPHIC PLATE COLLECTION USING THE NEW TECHNIQUE

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**ABSTRACT.** The paper presents the first results of processing of photographic observations of SS bodies based on materials from the collection of plates of the Ulugh Beg Astronomical Institute of the Academy of Sciences of the Republic of Uzbekistan (UBAI). The glass archive of the UBAI has about 15 thousand photographic plates with images of various space objects. In this paper, we discuss the first results of processing of major planets' photographic observations in Uzbekistan using the new technique. The observations were carried out on two astrographs – Tashkent normal astrograph (TNA, D/F=330/3438) and Kitab Double Zeiss astrograph (DAZ, D/F=400/3000) in 1895-2004. Currently, in AI the work runs to streamline the archive and create a database of observations in a single xls-format. The number of photographic plates with images of major planets obtained on two telescopes is more than 300 negatives. In 2017, together with MAO NAS of Ukraine, the processing of these photographic observations using the new methodology was started. By this time, in the framework of the UkrVO project (Vavilova, 2012a; Vavilova, 2012b; Vavilova, 2014; Vavilova, 2016; Vavilova, 2017) the method of reducing digitized plates was developed for the FON program. The plate digitization is performed on the flat-bed 10000XL in 1200dpi mode. Positions and photometric estimations in B-color of all registered on the plate objects are obtained using the software proposed and developed in MAO NAS of Ukraine running in the LINUX/MIDAS/ROMAPHOT complex.. The search for major planets and their satellites among the whole set of plate objects and the comparison of their observed and predicted positions is carried out online with the help of internet-service (<http://lnfm1.sai.msu.ru/neb/nss/nssephmr.htm>). Up to date, the small part of the plate collection was treated, namely 23 negatives with images of Uranus, Neptune, Pluto and Saturn's satellites, obtained on the Kitab DAZ astrograph. 16 negatives with 19 exposures gave the best results with (O–C) in the range  $\pm 1.5''$ . In total, we obtained 47 astrometric positions of the objects of interest in the wide interval of brightness's ( $8^m \pm 16^m$ ). The internal positional accuracy of the catalog in the Tycho-2

reference system is  $\sigma_{\text{ad}} = 0.08''\text{--}0.13''$ , the photometric error of B-magnitudes is estimated as  $\sigma_B = 0.2^m$ .

**Keywords:** digital plate processing – astrometry of Major planets – satellites – catalogues.

**АБСТРАКТ.** Архів склотеки Астрономічного інституту Академії Наук Республіки Узбекистан (UBAI) нараховує майже 15 тисяч фотопластинок із зображеннями різних об'єктів Космосу. В роботі йдеться про перші результати опрацювання спостережень Великих планет та їхніх супутників, зображення яких було отримано за допомогою двох астрографів – Ташкентського нормального астрографа (TNA) та Кітабського Подвійного астрографа Цейса (DAZ) в Узбекистані у подовж 1895-2004 років. На даний час в АІ виконуються роботи з упорядкування архіву платівок та створення Банку даних фотографічних спостережень у єдиному xls-форматі. Кількість фотопластинок із зображеннями Великих Планет становить понад 300 негативів. У 2017 році в АІ спільно з ГАО НАНУ розпочато опрацювання цих спостережень за новою методою. На той час, у рамках проекту УкрВО (Vavilova, 2012a; Vavilova, 2012b; Vavilova, 2014; Vavilova, 2016; Vavilova, 2017) був розроблений та запропонований метод редукції оцифрованих пластинок для програми ФОН. Оцифрування негативів здійснюється за допомогою планшетного сканера Epson Expression 10000XL в режимі 1200dpi. Подальша редукція оцифрованих платівок відбувається завдяки комплексу програм, спеціально розроблених в ГАО в операційному середовищі LINUX/MIDAS/ROMAFOT. За допомогою інтернет-сайта (<http://lnfm1.sai.msu.ru/neb/nss/nssephmr.htm>) в режимі online відшукуємо зображення Планет серед усіх об'єктів платівки та визначаємо розбіжності (O–C) між обчисленими та їх теоретичними положеннями. На даний момент опрацьовано невелику частку спостережного матеріалу (23 негатива) із зображеннями Урана, Нептуна, Плутона та супутників Сатурна, що були отримані на астрографі DAZ в Кітабі. Успішними виявилися 16 фотопластинок (19 знімків), для яких значення (O–C) не перевищує  $\pm 1.5''$ . Загалом, ми отримали 47 астрометричних положень Планет в

широкому діапазоні їх яскравості ( $8^m \div 16^m$ ). Внутрішня точність редукції RMS по обох координатах знаходиться в межах  $\sigma_{\text{об}} = 0.08'' \div 0.13''$ , а похибка визначення зоряної величини становить  $\sigma_B = 0.2^m$ .

**Ключові слова:** Опрацювання оцифрованих пластинок – астрометрія – великі планети – супутники – каталоги.

## 1. Introduction

The glass archive of UBAI possesses a vast collection of photographic observations having been obtained since 1895. The total number of direct plates with selected sky areas is 15 thousand. Observations on the Tashkent normal astrograph (TNA) were successfully performed until 1986. Later, the main observational activity was moved to the Kitab observational site. Here, in 1975 the Zeiss Double Wide-Angle astrograph DAZ (Yuldoshev, 2016; Yuldoshev, 2017a; Yuldoshev, 2017b) was installed for the observations on the FON project (Photographic survey of the northern sky) (Kolchinskiy, 1977; Pakuliak, 2016; Andruk, 2017b). Below, Table 1 gives the parameters of both telescopes. The archive of photographic plates got on DAZ in 2015 was moved from Kitab to Tashkent. Later, the works run to create the data bank of all observations in the single xls-format. In 2017, the photographic plate processing has been initiated together with MAO NAS of Ukraine. The archive of photographic plates got on DAZ in 2015 was moved from Kitab to Tashkent. Later, the works run to create the data bank of all observations in the single xls-format.

Table 1. Parameters of TNA and DAZ telescopes

Parameter	ТАШКЕНТ, TNA	Kitab, DAZ
ID	TAS033	TAS040A TAS040B
Marsden's Code	192	186
Longitude	69°17.'0	66° 53.'0
Latitude	41°19.'5	39° 08.'0
Altitude	482 m	690 m
Aperture	0.33 m	0.40 m
Focal length	3.43 m	3 m
Scale	60"/mm	69"/mm
Field	2°÷2.5°	5.5°÷6.0°
Glass plate size (max)	16x16cm	30x30cm

In 2017, the photographic plate processing has been initiated together with MAO NAS of Ukraine. The objects of interest were plates with images of major planets obtained in Uzbekistan on two telescopes. The renovation of the Institute building has temporarily complicated the access to the observational material. So, only 23 plates with Kitab DAZ observations were available and had been processed up to date.

## 2. The procedure of major planets' observation processing

The plate digitization was made using flat-bed commercial scanner Epson Expression 10000XL in grey color range 16-bits with a spatial resolution 1200 dpi (Protsyuk, 2014; Eglitis, 2017). The flat-bed scanner accompanied with the proper software allows digitizing and processing of plates containing objects of any brightnesses. The astrometric reduction of digitized data was made using the software proposed and developed in MAO NAS of Ukraine for the FON project (Relke, 2015; Andruk, 2015; Andruk, 2016a; Andruk, 2016b; Andruk, 2017a). The total package runs in LINUX/MIDAS/ROMAFOT operational environment. The initial scripts of the package were modified to meet the requirements of SS bodies' specific observations. In our case, the internal positional accuracy of the reduction lies in the range  $\sigma_{\text{об}}=0.10''$ , the accuracy of photometric estimations is better than  $\sigma_B = 0.2^m$ . Table 2 contains the results of processing 16 plates with Neptune, Uranus and its satellite Oberon, Pluto, and five Saturn's moons. The catalog of observed topocentric positions and the results of their comparison with theoretic data is given in Table 3. The observations which have the discrepancies with the theory more than  $\pm 2.5$  arcsec were not included to the catalog. The plates required the more accurate moments of observations were excluded as well.

## 3. Conclusions

The first 47 topocentric positions of major planets and their satellites were obtained from DAZ observations. The processing of photographic observational data was made using algorithms of digital data reduction and the software developed in MAO NAS of Ukraine. Earlier, the same technique was tested and proved for the search for asteroids and satellites of major planets (Protsyuk, 2017; Shatokhina, 2016; Shatokhina, 2017; Yizhakevych, 2014; Yizhakevych, 2015; Yizhakevych, 2016; Yizhakevych, 2017a; Yizhakevych, 2017b). The comparison of observed positions of objects with those of online ephemeris data of IMCCE demonstrates the good agreement of the theory and observations.

In the future, we plan to go on with the processing of photographic plates from UBAI glass collection containing the images of Solar system bodies obtained in Uzbekistan on two astrographs.

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Table 2. The statistical data of the reduction of SS bodies observations made in Kitab (DAZ):

1 – object name; 2-years of observations; 3 – number of plates /number of observational nights;  
 4 – number of positions, 5 – photographic stellar magnitude; 6,8,10 – standard deviation; 7,9 – (O-C) on right  
 ascension and declination; 11, 12,13 – RMS – internal error of the reduction;  
 14 – number of reference stars from Tycho-2.

Obj	Range	N pl. /N nights	N pos.	Bph	Sd Bph	O-C R.A.	Sd R.A.	O-C Del.	Sd Del	RMS			n
										Bph	R.A	Del	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
<b>SATURN'S MOONS</b>													
S5	1983, 1990	4/4	8	10.3	.44	-0.53	.77	+0.36	.56	.29	.08	.09	1277
S6	1983, 1986, 1990	6/6	10	9.9	.19	+0.13	.59	-0.04	.36	.28	.09	.09	1194
S7	1990	3/3	3	15.0	.20	-0.00	.35	-0.09	.14	.28	.07	.08	1725
S8	1990	4/4	6	12.8	.20	+0.05	.22	-0.19	.31	.29	.09	.10	1676
S9	1990	1/1	1	16.6		+3.96		+1.04		.28	.06	.07	1675
<b>Σ</b>	1983- 1990	6/6	27										
<b>URANUS</b>													
Ura- nus	1983, 1985	3/3	6	7.5	1.34	-0.13	.57	-0.35	.34	.33	.13	.14	630
U4	1979, 1983 1985	4/4	4	13.9	0.72	+0.13	.94	+0.44	.82	.30	.08	.08	729
<b>Σ</b>	1979- 1985	7/7	10										
<b>NEPTUNE</b>													
Nep- tune	1983, 1984	4/4	9	8.4	0.48	+0.05	.64	0.11	.45	.33	.13	.14	2245
<b>PLUTO</b>													
Plu- to	1990	2/2	3	13.7	0.15	-0.19	.05	-0.25	.19	.29	.06	.07	527

Table 3. The catalog of topocentric positions of major planets and their satellites from observations on DAZ astrograph in Kitab:

1 – Date+UT in fractions of day; 2 – Right Ascension (h,m,sec); 3 – Declination (degrees, min.,arcsec); 4 – exposure (min.);  
 5 – photographic magnitude; 6,7 – (O-C) on Right Ascension and Declination (arcsec); 8 – number of plate.

Date, UT			RA			DEC			Exp.	B <sub>ph</sub>	(O-C) <sub>α</sub>	(O-C) <sub>δ</sub>	NPI.
1			2			3			4	5	6	7	8
Y	M	Day	h	m	s	°	'	"	min	mag	"	"	
<b>NEPTUNE</b>													
1983	09	11.656048	17	45	44.237	-22	10	49.307	15	8.7	1.06	0.10	17
1984	06	21.762796	18	01	4.906	-22	13	29.341	2	8.6	0.22	0.64	1645
1984	06	21.769491	18	01	4.904	-22	13	29.758	15	7.6	0.91	0.23	1645
1984	06	21.775954	18	01	4.822	-22	13	30.408	2	8.6	0.37	-0.42	1645
1984	06	24.795219	18	00	43.611	-22	13	32.322	2	8.8	-0.62	-0.10	1753
1984	06	24.801625	18	00	43.592	-22	13	32.551	15	7.6	-0.22	-0.33	1753
1984	06	24.814891	18	00	43.552	-22	13	31.947	2	8.7	0.59	0.29	1753
1984	06	27.781188	18	00	22.902	-22	13	34.920	36	8.8	1.20	-0.28	1718
1984	06	27.800493	18	00	22.762	-22	13	33.755	5	8.5	1.15	0.90	1718
<b>PLUTO</b>													
1990	06	13.778986	15	10	36.276	-01	17	4.240	30	13.9	-0.23	-0.47	1822
1990	07	17.722097	15	08	38.607	-01	25	31.984	21	13.6	-0.22	-0.14	1850
1990	07	17.725559	15	08	38.613	-01	25	32.081	21	13.7	-0.13	-0.14	1850

U4 OBERON													
1979	07	14.693111	14	59	34.990	-16	41	24.500	15	13.5	-0.60	1.44	470
1983	07	2.686363	16	16	37.989	-21	12	50.224	15	13.8	-0.52	-0.56	1529
1985	09	5.651112	16	51	39.235	-22	32	55.360	15	15.0	0.12	0.38	1376
URANUS													
1983	04	14.934433	16	28	57.093	-21	41	18.023	17	5.6	0.23	-0.60	1619
1983	04	14.941162	16	28	56.967	-21	41	17.559	3	6.6	-0.98	-0.23	1619
1983	07	2.686366	16	16	36.535	-21	13	28.697	15	9.0	0.40	-0.92	1529
1985	09	5.641802	16	51	36.362	-22	33	9.358	2	7.5	0.43	-0.13	1376
1985	09	5.644533	16	51	36.313	-22	33	9.422	2	7.5	-0.42	-0.18	1376
1985	09	5.648381	16	51	36.323	-22	33	9.324	15	9.0	-0.44	-0.06	1376
S5 RHEA													
1983	04	13.862186	14	03	3.460	-09	34	28.083	3	10.3	-0.20	0.14	1433
1983	04	13.864896	14	03	3.422	-09	34	27.878	3	10.3	-0.27	0.15	1433
1983	04	13.867666	14	03	3.376	-09	34	27.794	3	10.3	-0.44	0.04	1433
1990	07	14.744142	19	35	42.985	-21	32	58.089	15	10.3	-0.24	0.31	1842
1990	07	16.766385	19	34	53.635	-21	34	23.908	15	10.7	0.40	-0.24	1847
1990	07	19.774135	19	34	6.618	-21	37	16.724	1	10.5	-0.75	0.22	1862
1990	07	19.780367	19	34	6.362	-21	37	15.775	15	9.3	-2.26	1.60	1862
1990	07	19.786600	19	34	6.326	-21	37	17.137	1	10.7	-0.46	0.68	1862
S6 TITAN													
1983	04	13.862186	14	02	47.294	-09	34	22.163	3	9.9	0.07	-0.12	1433
1983	04	13.864896	14	02	47.259	-09	34	21.608	3	9.9	0.16	0.13	1433
1983	04	13.867666	14	02	47.177	-09	34	21.522	3	9.9	-0.44	-0.09	1433
1986	06	29.724425	16	11	20.692	-19	05	53.813	1	9.7	1.58	-0.10	1425
1990	07	14.744142	19	35	24.083	-21	32	47.862	15	9.8	0.07	-0.09	1842
1990	07	15.732411	19	35	5.256	-21	33	6.876	15	9.8	-0.15	0.18	1844
1990	07	16.766385	19	34	47.665	-21	33	31.633	15	9.8	0.16	-0.17	1847
1990	07	19.774135	19	34	5.029	-21	35	39.340	1	9.8	-0.13	0.74	1862
1990	07	19.780367	19	34	4.986	-21	35	41.142	15	9.9	0.51	-0.68	1862
1990	07	19.786600	19	34	4.830	-21	35	40.987	1	10.4	-0.54	-0.15	1862
S7 HYPERION													
1990	07	14.744142	19	35	24.110	-21	31	48.484	15	15.2	0.17	-0.22	1842
1990	07	15.732411	19	35	8.372	-21	32	18.102	15	15.0	-0.41	0.06	1844
1990	07	19.780367	19	34	10.289	-21	35	37.961	15	14.8	0.23	-0.09	1862
S8 IAPETUS													
1990	07	14.744142	19	36	13.530	-21	33	20.375	15	12.7	-0.02	-0.18	1842
1990	07	15.732411	19	35	55.746	-21	34	14.853	15	12.8	0.36	0.17	1844
1990	07	16.766385	19	35	36.792	-21	35	12.787	15	12.7	-0.18	-0.76	1847
1990	07	19.774135	19	34	40.299	-21	37	54.795	1	12.7	-0.04	-0.07	1862
1990	07	19.780367	19	34	40.199	-21	37	55.180	15	12.9	0.28	-0.12	1862
1990	07	19.786600	19	34	40.054	-21	37	55.598	1	13.2	-0.07	-0.21	1862
S9 Phoebe													
1983	07	11.689238	16	15	30.593	-21	10	49.381	15	9.5	3.63	1.86	1614

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