Observations of Small Space Objects At the Terskol and Zvenigorod Observatories of INASAN

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INTRODUCTION

Regular observations by CCD-cameras of small space objects in geostationary orbits were started in the Terskol and Zvenigorod observatories of the Institute of Astronomy of the Russian Academy of Sciences (INASAN) in 2006. Current primary tasks: regular GEO monitoring, discovery, and tracking of new small objects, photometry of tracked objects. New instruments to observe small space objects by the Zvenigorod and Terskol observatories were installed in 2009. Observations are performed using the GPS-timing system and the APEX software package for CCD frame processing and camera control developed in Pulkovo Observatory of RAS [1], [2]. In June - October 2009 at Terskol observatory during 18 nights more than 13000 positions were determined of 80 small SO, 17 of them were never observed before.

OBSERVATIONS IN TERSKOL OBSERVATORY

Terskol Observatory is located in Kabardino-Balkaria, Republic of Russia ($\varphi = +43^0$ 16' N, λ = 2h 50m E, H = 3100 m) near the Elbrus mountains (Fig. 1). The main researches are conducted on the Zeiss-2000 telescope [3]. Until 2009 we have used a focal reducer of Max-Planck-Institute (MPAe, Germany) with a CCD camera of "FOTOMETRICs". In 2009 we have installed a CCD camera FLI PL4301 on the RC focal plane. The old and new CCD-camera's parameters are given in the table 1. Many fragments of space debris, not presented in catalogues, are found, e.g. an unknown fragment of 18th mag. with a high AMR was detected in May 20, 2007. During the next four nights about 400 positions of this object were measured. The mean elements of the orbit at the Epoch 21.05.2007 (MJD = 54241.0) are: e = 0.0166364, i = 9.74924 deg, Ω = 330.46317 deg, ω = 208.20954 deg, M = 124.84926 deg, n = 1.004220328 rev/ day, AMR - ~2 m^2/kg. The brightness changes are given in Fig.2. Later this object was catalogued in KIAM as small space object number 90060.
In June and October, 2009 13000 positions were measured of 80 small objects, 17 of them – "new" ones. Orbital parameters of the new object No 95334 observed during 6 nights are given below.

- No 95334
- E 15 10 2009
- UT 23 32 45.170
- a 41715.5571
- e 0.0299128
- i 14.004877
- Ω 347.869916
- ω 163.459005
- M 300.36802113
- n 1.011308e-08 km/s^2
- A/m 2.217 m^2/kg

The accuracy of the positional observations are estimated by orbit approximation, as illustrated in

the table 2.

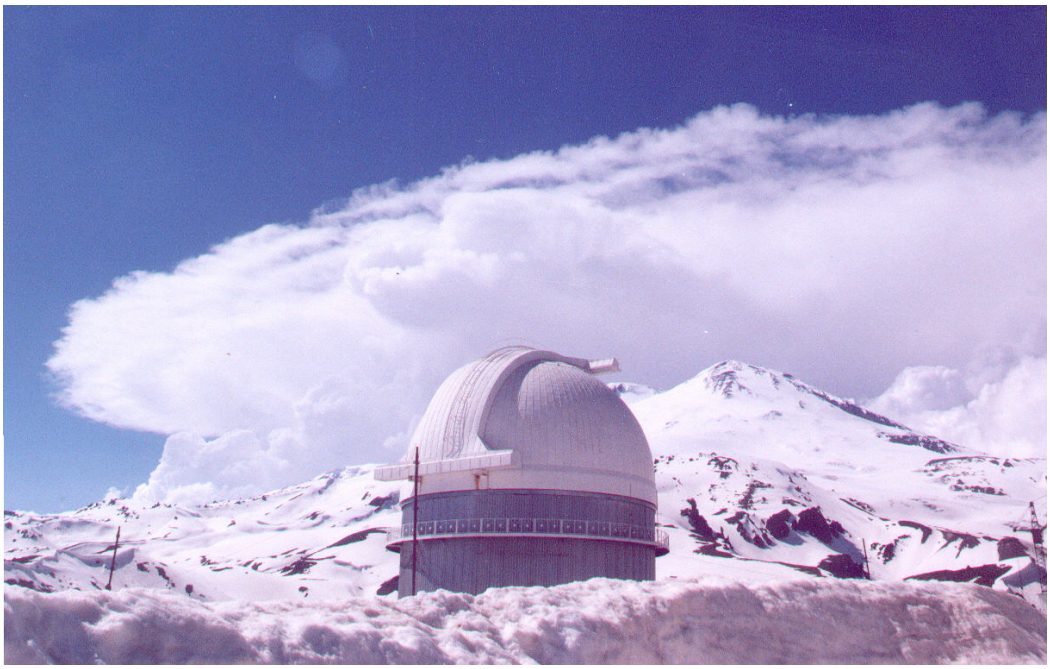

Fig. 1. Dome of the Zeiss-2000 telescope. In the background – Elbrus mountains.

Table 1. Parameters of the old and new CCD-cameras of the Zeiss-2000 telescope.

	CCD camera of "FOTOMETRICs" with the focal reducer	CCD camera FLI PL 4301 in the RC focus
Aperture	2 m	2 m
Focal length	~6.3 m	16 m
CCD size	561 x 512 pixels	2084 x 2084 pixels
Pixel size	~27 x 27 mkm	24 x 24 mkm
Field of view	8 x 8 arcmin	~ 12 x 12 arcmin
Read-out time	10 – 20 sec	2 – 5 sec
Detection threshold on GEO	20 mag	21 mag

Pixel size	~27 x 27 mkm	24 x 24 mkm
Field of view	8 x 8 arcmin	~ 12 x 12 arcmin
Read-out time	10 – 20 sec	2 – 5 sec
Detection threshold on GEO	20 mag	21 mag

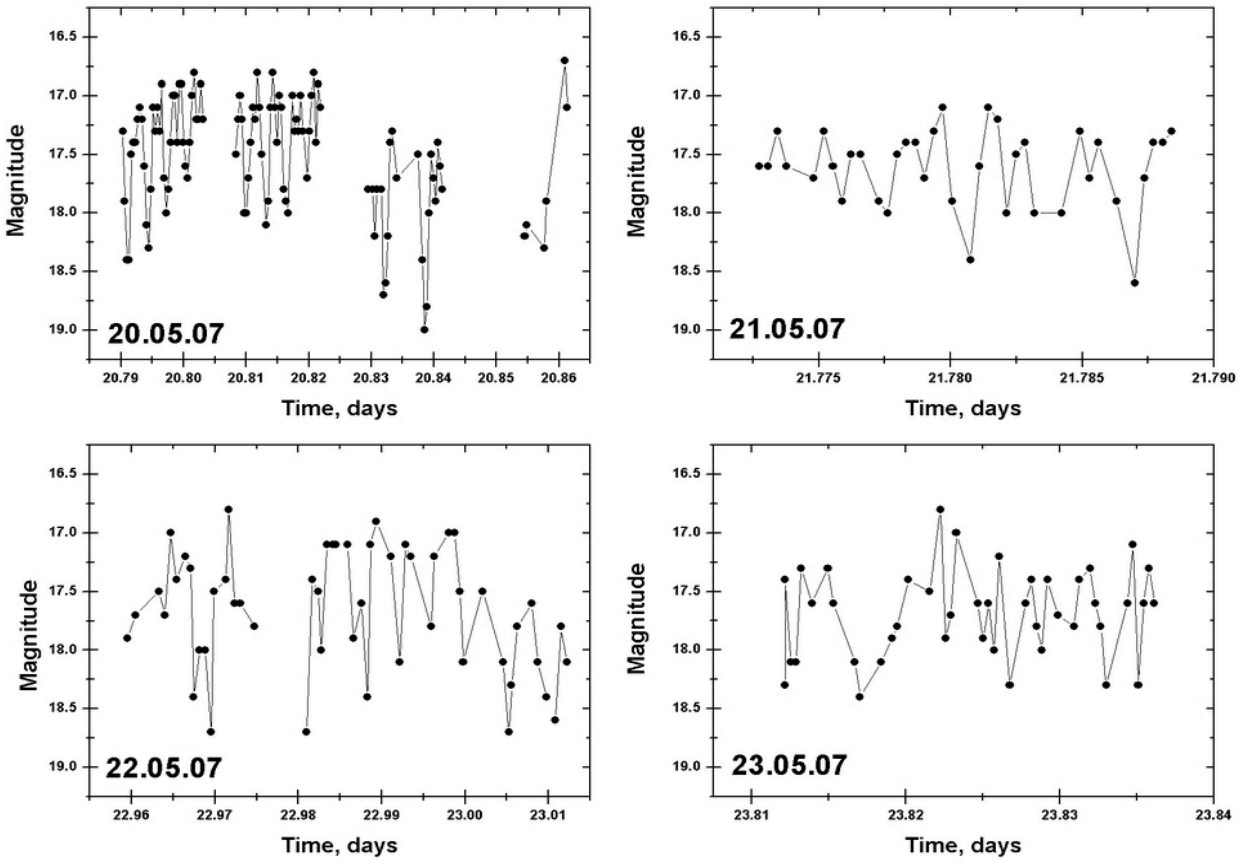

Fig. 2. Brightness changes of the unknown small-size GEO object, detected in Terskol observatory on May 2007.

Table 2. Accuracy of the positional observations of small space objects performed in Terskol Observatory in June 2009. N –number of positions, m – number of nights of observations, σ - RMS of one position in arcsec, min, max – min and max residuals in arcsec.

Object No	N	m	σ	min	max
90032	134	3	0.295	-1.029	1.035
90051	95	3	0.367	-1.079	1.226
90073	163	5	0.466	-1.836	1.825
90089	89	2	0.275	-0.708	0.704
90114	108	4	0.414	-1.212	1.039

OBSERVATIONS IN ZVENIGOROD OBSERVATORY

Zvenigorod Observatory is located 40 km from Moscow ($\varphi = +55^0$ 41' N, $\lambda = 2$ h 27 m E, H = 180 m). The observatory is one of the oldest optical satellite tracking stations and operates since 1959 (Fig. 3). Most of the satellite tracking instruments (there are 8 optical instruments with an aperture more than 20 cm) are not used now in space debris researches. A photographic camera, VAU, for satellite observations was installed in 1969. VAU has Maksutov's system optics which

are installed on a three-axis mount (Fig. 4). A high accuracy tracking speed is possible in four bands:
0 – 6, 6 – 60, 60 – 600, 600-6000 arcsec per sec. Now we have replaced the front guide-telescope of the VAU with a wide-angle Hamilton's camera (Santel-500 telescope), produced by A. Sankovitch in OOO "Santel-M" (with the CCD-camera Fli PL9000). The parameters of the VAU and new telescope are given on the table 3.

Fig. 3. A view of the Zvenigorod observatory of INASAN.

Fig. 4. Santel-500 telescope on the VAU camera during observations.

Table 3. Parameters of the VAU and Santel-500 telescope.

	VAU	Suatel-500
D of main mirror	100cm	50cm
Aperture	50 cm	50 cm
Focal length	70 cm	125 cm
Detector	Film	CCD-CAMERA FLI PL9000
CCD size	-	3056 x 3056 pixels
Pixel size	-	12 x 12 mkm
Field of view	30 x 5 deg	1.65 x 1.65 deg
Detection threshold on GEO	15 mag	Up to 18 mag

SUMMARY

New techniques for space research are being developed in the Institute of Astronomy. The wide angle 50-cm aperture Santel-500 telescope with the 3 K x 3 K CCD camera is installed on the three axis tracking mount of VAU camera in Zvenigorod Observatory. Now it is possible to observe small space objects in GEO, GTO, HEO and MEO. The Zeiss-2000 telescope of the Terskol Observatory is equipped with a new CCD camera, FLI PL 4301 (2 K x 2 K, pixel size 24 mkm x 24 mkm) which increases the efficiency of the space objects observations four-five times. Now we can detect 10 cm size objects in GEO. Future activities will be conducted with photometrical and spectral measurements of space objects.

REFERENCES

[1] Rusakov O.P., Kouprianov V.V., “Equipment for synchronization of measurements with the GPS-timing system on module "Trimble Resolution T"”, http://lfvn.astronomer.ru/report/0000018/GAO/index3.htm.

[2] Vladimir Kouprianov. “Distinguishing features of CCD astrometry of faint GEO objects”, Advances in Space research, vol. 41 pp. 1029-1038, 2008.

[3] V.Tarady, Ya.Yatskiv, “The New 2m RCC Telescope in the Northern Caucasus for Modern Astronomical Research “, Astron.Astrophys.Trans, N 13, pp.19-21, 1997.

[4] N. Bakhtigaraev, A. Sergeev. Observations of Space Debris in GEO. Proceedings of 5th European Conference on Space Debris, ESA SP-672, July 2009.

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