Possibilities of the Bulgarian National Observatory for Astrometric and Photometric Observations of Asteroids

V. Ivanova[1], V. Shkodrov[1], G. Apostolovska[2], G. Borisov[1], B. Bilkina[1]

[1] Institute of Astronomy, Bulgarian Academy of Sciences
72, Tsarigradsko Chaussee Blvd., BG–1784 Sofia, Bulgaria
[2] Institute of Physics, Faculty of Natural Sciences
P.O. Box 162, 91000 Skopje, R. Macedonia

Abstract

The equipment of the Bulgarian National Observatory – Rozhen for observations of asteroids and comets, are presented. Some results of astrometric and photometric observations of minor planets, their accuracy and future are discussed.

1 Introduction

The Bulgarian National Astronomical Observatory (BNAO)–Rozhen is in operation over twenty years. From its first days of exploitation there were carried out positional observations of asteroids. Active observations were mentioned out (Marsden, 1983). This activity continued until 1990 when astronomical observatories began using CCD cameras. That was far beyond the finances of the Institute of Astronomy. So, for a period of time our observational work was restricted. In the mean time we extended the subject of our research with photometric observations of asteroids, but we needed time to obtain the first results. Now the situation is better and we would like to present improved observing capacity of BNAO, photometric and astrometric results obtained until now and in this connection to clarify our position in the networks discussed on this workshop.

2 NAO Rozhen

NAO Rozhen is still the largest one in South-Eastern Europe. It is situated in Rodope mountains, South-Western Bulgaria on 1750 m altitude, $\lambda = 1^h 38^m 52^s$ and $\varphi = +41°43'$. Physically dark time is 3050 hours per year with meteorological efficiency 40%. The mean seeing is not better than 2". The distance from Sofia, where the Institute of Astronomy is situated is 250 km. In NAO Rozhen there are 3 optical telescopes. Parameters of the equipment are presented in Table 1.

Table 1: Telescopes in NAO – Rozhen

	2m RCC telescope	50 cm/70 cm Schmidt telescope	60 cm telescope
1/f	8	3.44	12.5
Resolution	12.89 "$/mm$	120 "$/mm$	27"$/mm$
FOV	$1^\circ \times 1^\circ$	$5^\circ \times 5^\circ$	$20'$
	CCD Photometrics	CCD SBIG ST–8E [1]	
	CE200A – SITe	Kodak KAF–1602E	Photomultiplier
Detector	$1024 \times 1024 px^2$	$1536 \times 1024 px^2$	EMI-9789QA
	$1px = 24\mu m$	$1px = 9\mu m$	Pulse counting
Cooling	Liquid nitrogen	Thermoelectric	without cooling
FOV	$5' \times 5'$	$27.'6 \times 18.'4$	
Filters	$UBVRI$	$UBVRI$	UBV

2m Ritchey-Chretien-Coude telescope is operating in two focuses – RC and Coude. A focal reducer Rozhen "*FoRoRo*" is designed for comet observations; $f = 7,2\,m$, field of view $11.'7 \times 11.'7$. The Coude Focus is working with horizontal stellar spectrograph with 20 cm and 30 cm wide beams.There are three high resolution cameras available - 4Å/mm, 9Å/mm and 18Å/mm.
There is one more 60 cm Cassegain telescope which belongs to the Institute of Astronomy, situated in Belogradchik - North-Western part of Bulgaria, $\lambda = 1^h 30^m 42^s$ and $\varphi = +43^\circ 37'$. It is possible an electrophotometer or CCD camera SBIG ST-8 to be attached to it.
One of the problems of the BNO is the small amount of available CCD cameras, which don't allow different cameras to be used with the telescopes depending on the task. For example a device of $2K \times 2K$ class will be of great advantage for positional observations with our Schmidt telescope.

3 Astrometry

The first systematic observing programme of the NAO was astrometry of asteroids. It was carried out primary with Schmidt telescope and if it was required also the 2m telescope was used. For example the first photography of the Comet P/Halley from Europe was obtained with 2m telescope on 25^{th} November 1984, when its magnitude was 22^m (Shkodrov *et al.*, 1986).
Before starting the astrometric programme we had developed observational methods and reduction software (Ivanova, 1977). The $(O-C)$ were well conformed with those published in the MPCs from other authors. For CCD observations the following software have been used: "ASTROMETRICA" by H. Raab and "Charon" by the project PLUTO.
The main observational programmes were: for new discoveries and for the needs of the Ephemerides Survey. After we were invited by E. F. Helin together

[1] The camera was bought with the help of the University of Skopje, Macedonia and a Space Frontier Foundation grant.

with the Mount Palomar observatory and the Caussol (Observatory de la Cote d'Azur) we took part in the first international programme searching for fast moving objects (INAS).
For astrometry we get 7 nights per month of the observing time of the Schmidt telescope which we use in co-operation with Macedonian colleagues.
Some results from astrometric asteroid observations are presented in fig 1

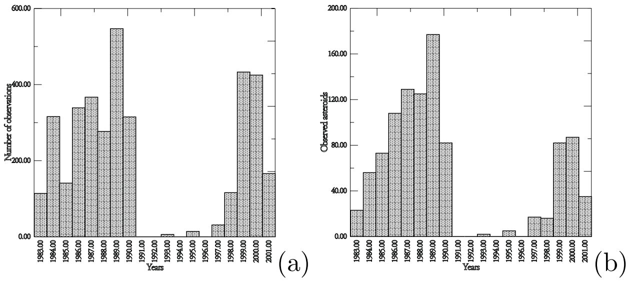


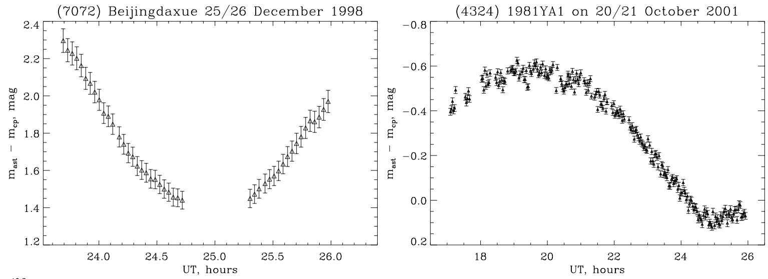
Figure 1: Statistic of astrometric observations

4 Photometry

Regular photometric observations have been carried out since 1991 with 60 cm Cassegrain telescope. For photometry of faint objects the 2m telescope can be used also. So, in winter of 1993, according to the International campaign for modelling of this object (Magnusson et al, 1996), it was used for relative photometry of 1620 Geographos.
In the same time we made a lot of preliminary work on method of observations and their reduction. On the base of existing software for electrophotometric data reduction of stelar objects (Kirov *et al.*, 1991), it was made another software for reduction of asteroids photoelectric data (Denchev, 1996), according to specifics of these objects and the requirements for layout of the end results. We would stress on two moments of this software. First of all it is considered recommendation of (A. Haris et al, 1989) for calculations of first order extinction coefficient using comparison star. It also takes into account the second order extinction coefficient. The software gives a possibility the errors on every stage of reduction to be estimated.
Since the beginning 43 asteroids was observed photoelectric and 14 – with CCD. Results for 27 objects were published. In order to have some impression of the accuracy we present here three lightcurves or part of them (Fig. 2) taken with three different telescopes.
For photometric observations of asteroids and comets we get average 18 nights per half-year on 2m and about 20 on Cassegrain telescope. For photometry we use also a part of observational time on the Schmidt telescope of BNAO.

Conclusion

As can be seen from Fig 1(a) the efficiency of the astrometric observations made with the CCD camera ST-8E is comparable with that achieved with astroplates.



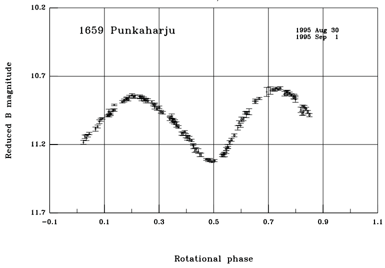


Figure 2: Lightcurves of three asteroids obtained with 2 m RCC, 50 cm/70 cm Schmidt and 60 cm Cassegrain telescopes, respectively

This encourage us to continue the positional observations. In the same time the number of observed asteroids (Fig 1(b)) decrease a while because of small FOV. Taking into account this circumstance and importance of "follow up" these observations of NEOs are preferred.

The photometric observations of small planets will continue for determination of their rotational and physical parameters. A special attention will be point at NEOs and distant object. Current facilities of the observatory allow observation of mutual event between the satellites of the giant planets in the Solar System (Arlot *et al.*, 1997) and also occultation of stars by asteroids. And finally, we think that the observational possibilities of BNAO Rozhen will be used more effectively in a better integrity with colleagues from other countries.

References

[1] Marsden B., *Inf. Bull. IAU*, **54**, June, 1983, p.11.

[2] Shkodrov, V.G., Bonev, T.R., Ivanova, V.G., 1986, *Comp. rend. Acad. bulg. Sci.*, **39**,1, pp.11-13.

[3] Ivanova, V.G., 1977, *NISZ*, **16**, p. 333.

[4] Kirov, N.K., Antov, A.P., Genkov, V.V., 1991, *Comp. rend. Acad. bulg. Sci.*, 1991, **44**, pp. 5-8.

[5] P. Denchev, *PhD Thesis.*

[6] Harris A.W., and Lupishko, D.F., 1989, *in Asteroids II*, pp. 39-53.

[7] Arlot, J.E. ... Shkodrov, V.G.,... *et al.*, 1997, *A&ASS*, **125**, pp. 399-405.

[8] Magnusson, P., ... V. Ivanova, B. Komitov, Z. Donchev, P. Denchev,.... *et al.*, 1996, *Icarus*, **123**, pp. 227-244.