S E S 2 0 1 4
Tenth Anniversary Scientific Conference with International Participation
SPACE, ECOLOGY, SAFETY
12 – 14 November 2014, Sofia, Bulgaria

NIGHT SKY BRIGHTNESS OVER THE ROZHEN NATIONAL ASTRONOMICAL OBSERVATORY

Tsvetan Georgiev

New Bulgarian University
Institute of Astronomy and NAO – Bulgarian Academy of Sciences
e-mail: tsgeorgiev@nbu.bg

Keywords: *Night sky brightness*

Abstract: *Estimations of the night sky brightness are derived in the surface photometry of nearby galaxies, observed in 2003-2004 by the Schmidt telescope of the Rozhen NAO, Bulgaria, at 1750 m over the sea level, in an epoch of solar maximum. The average sky magnitudes in the BVR_C I_C bands occur 21.3, 20.7, 203 and 18.7 mag/sq.arcsec, respectively. The observed objects were placed up to 30 degree from the zenith and the standard error of the estimations is about 0.2 mag. The increasing of the night sky brightness is due to the grow of the nigh illuminations in the surrounding towns and villages in the period 1983-2003 is estimated to be about 0.4 mag or 1.4 times. Estimations of the brightness of the night sky over other astronomical sites are collected too.*

Introduction

The night sky brightness (NSB) restricts the deepness and accuracy of the astronomical photometry. In his classical work Garstang (1989) determined the natural NSB s to be 22.0 mag/sq.arcsec in V-band and 23.0 mag/sq.arcsec in B-band. At that time the most dark sky is registered occasionally over San Benito Mountain, V=22.06 mag/sq.arcsec, in 1976, as well as over Mauna Kea, B=23.05 mag/sq.arcsec in 1987.

Many contaminates to the NSB are well known – extragalactic background, unresolved stars of the Milky Way (in dependence on the galactic latitude), zodiacal light (in dependence on the ecliptic latitude), solar-cycle phase, artificial airglows (in dependence on zenith distance and azimuth), elevation above the sea level etc. (Walker 1970; Roch & Gordon 1973). Moreover, the airglow depends on the atmosphere transparency, which fluctuates by minutes, hours, days, seasons, years, epochs etc. So, the correct estimation of the NSB is a complicated task that needs many observations in a long period of time.

However, single approximate data are very useful too. This paper reports estimations of the NSB over Rozhen NAO in 2003-2004 . Collections of such data for other observing sites is present too.

The method and the results about Rozhen NAO

These estimations of the NSB are a buy product of the surface photometry of a few nearby galaxies (Georgiev, 2014). The observations were carried out in the summers of 2003and 2004 by the 50/70/170 cm Schmidt telescope of the Rozhen NAO, in the Rhodope Mountains, at 1750 m elevation. A CCD camera ST8 with scale 1.1 arcsec/pix and field 18x27 arcmin was explored. Shot filters with 3 mm thickness were used for BVRI bands (hereafter wew mwans BVR_C $I_{C)}$, as follows: 1BG13+1BG12+1BG39, 2GG495+1BG39, 1BG570+2KG3, 3RG9.

The radial profiles of the galactic images and the background estimations are based on the median pixel values of numerous concentric elliptical rims, centered on the galaxy nucleus. The axial ratio and the position angle of the rim system were adopted to fit the faint periphery of the galaxy image. The background value is estimated by the profile on distances from the center of the image that is 2-3 times larger than the radius at surface brightness 25 mag.arcsec^{-1} in B band. This radius of the galactic image is extracted from the data in NED (NASA/IPAC Extragalactic Database, 2014) and HyperLeda (Université Claude Bernard, Lyon 1,2014).

Average NSB over Rozhen NAO in 2003-2004, in BVRI bands and respective standard deviations (in parentheses) , are: B = 21.28 ±0.29 , V=20.69 ± 0 .23, R = 20.33 ± 0.16 and I = 18.73

± 0.12 mag/sq.arcsec, respectively. The numbers of the estimations in different bands are between 5 and 8.The results of the single NSB estimations are presented on Fig.1

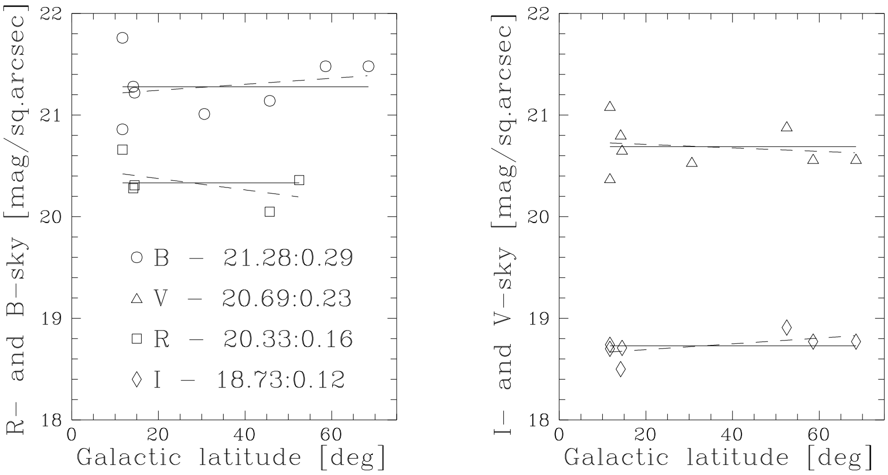

Fig. 1. Single estimations of the NSB over the Rozhen NAO in 2003-2004. Left panel: in B and R bands . Right panel: in V and I bands. Solid lines: levels of the average values. Dashed lines show the regressions on the galactic latitude of the used galaxy

The NSB in I band seems to be too high. It may be explained in particular by the sensitivity of the used CCD in the near infrared in combination of the lack of bounding filter for the long light waves. Generally, the number of the estimations is not high, the disturbing factors are many and the dependence on the galactic latitude occurs not significant (Fig.1).

The increasing of the Rozhen NSB in the period 1983-2003 is estimated to be about 0.4 mag or 1.4 times.

Other estimations of the night sky brightness

Garstang (1989) has been collected many data about NSB over astronomical observing sites. A part of these data are reproduced in Table 1. Many other estimations of the NSB have been published later. Some of them are collected in Table 2.

Neizvestny (1982) published observations of the NS over the SAO (USSR) in the Nord Caucasus, at 2050 m elevation. The observing period is 1976-181, in a solar-cycle maximum. He found average NSB with standard error about 0.05 mag as follows: 22.55 mag/sq.arcsec in B, 21.42 mag/sq.arcsec in V and 20.39 mag/sq.arcsec in R_J. The color index is 1.07.

Krisciunas (1997) reported observations of the NSB at 2800 m over the sea side near to the Mauna Kea Peack in 1985-1996, in a period of one solar cycle. He found the NSB in V-band is varying from 21.3 mag/sq.arcsec in the solar maximum to21.9 mag/sq.arcsec in the solar minimum, The mean value is 21.6 mag/sq.arcsec. The color-index remains practically constant: (B-V) = 0.93 .

Table 1. Night sky brightness in V-band after Garstang (1989)

Ste	Year	V-NSB	Ste	Year	V-NSB
Mauna Kea	**1980**	**21.96**	**Cerro Tololo**	**1987**	**21.58**
Kitt Peak	**1987**	**21.92**	**Mount Palomar**	**1972**	**21.50**
Sacramento Peak	**1978**	**21.86**	**McDonald**	**1960**	**21.25**
San Pedro Martir	**1970**	**21.85**	**Lick**	**1973**	**20.37**
Mount Hopkins	**1980**	**21.82**	**Nount Wilson**	**1973**	**19.80**

Benn & Ellison (1998) published data about NSB in La Palma for the period 1987-1996. They found the median sky brightness at high elevation, high galactic latitude and high ecliptic latitude, at sunspot minimum, to be B = 22.7 mag/sq.arcsec, V = 21.9 mag/sq.arcsec, R = 21.0 mag/sq. arcsec, similar to that at other dark sites. The main contributions to sky brightness are airglow and zodiacal light. The sky is brighter at low ecliptic latitudes (by 0.4 mag), at solar maximum (by 0.4 mag), and at high airmass (0.25 mag brighter at airmass 1.5).

Table 2. Collection of estimations of the night sky brightness in BVRI bands

Site	Years	B	V	R	I	B-V	V-R	R-I	B-R	V-I	Cit.
SAO, Russia	1976-1981	22.6	21.4	20.4	-	1.2	1.0	-	1.8	-	1
Mauna Kea*	1985-1996	22.5	21.6	-	-	0.9	-	-	-	-	2
La Palma	1987-1996	22.7	21.9	21.0	-	0.8	0.9	0.9	1.7	-	3
Paranal	2002	22.6	21.6	20.9	19.7	1.0	0.7	1.2	1.7	1.9	4
Paranal	1992-2006	22.7	21.7	20.9	19.6	1.0	0.8	1.3	1.8	2.1	5
CTIO	1992-2006	22.8	21.8	21.2	19.8	1.0	0.6	1.4	1.6	2.0	6
Calar Alto	2004-2007	22.9	22.0	21.4	19.2	0.9	0.6	1.2	1.5	2.8	7
Skinakas Obs.	2008	22.4	21.6	21.1	-	0.8	0.5	-	1.4	-	8
Mount Graham	2008	22.8	21.8	20.8	19.8	1.0	1.0	1.0	2.0	2.0	9
Padova Obs.	1987	20.9	20.2	-	-	0.7	-	-	-	-	10
Padova Obs.	1993	20.4	19.9	-	-	0.5	-	-	-	-	10
Rozhen Obs.	1983	21.8	20.8	-	-	1.0	-	-	-	-	11
Padova Obs.	1985	21.7	20.9	-	-	0.8	-	-	-	-	12
Rozhen Obs.	2003-2004	21.3	20.7	20.3	18.7	0.6	0.4	1.6	1.0	2.0	13
KrAO	2008	-	20.8	-	-	-	-	-	-	-	14

1. Neizvestny (1982); 2.Krisciunas (1997); 3.Benn & Ellison (1998); 4.Patat (2003); 5.Krisciunas et al. (2007); 6.Krisciunas et al. (2007); 7.Sanchez et al (2007); 8.Skinakas Observatory(2008); 9.Redani (2009); 10.Cinzano (2000); 11. Afanasiev (1983); Panov {1985); 13.This work;14. Grankin (2009). * Not over the peak, but At 2880 m over the sea level.

Patat (2003) estimated the typical NSB for Paranal and found that it is similar to those reported for other astronomical dark sites at a similar solar solar cycle phase. The zenith-corrected values averaged over the whole periodin UBVRI-bands are, respectively, 22.3, 22.6, 21.6, 20.9 and 19.7 mag/sq.arcsec, respectively.

Krisciunas et al. (2007) reported estimations of the average NSB over CTIO and Paranal in BVRI bands, in the period 1992 – 2006, with typical standard error 0.2, follows. For CTIO: 22.82, 21.79, 21.19, 19.85 mag/sq.arcsec and for Paranal: 22.66, 21.69, 20.91, 19.65 mag/sq.arcsec , respectively.

Sanchez ey al (2007) estimated the NSB over Calar Alto site and reported that the zenith-corrected values of the moonless NSB in UBVRI bands are 22.39, 22.86, 22.01, 21.36, and 19.25 mag/sq.arcsec, respectively. He clame that Calar Alto is a particularly dark site for optical observations up to the I band. The observing period is 2004-2007.

The NSB over the Scinakas Observatory (Crete Island) with standard error ~0.15 is B=22.36 ± 0.16, V =21.60 ± 0.14 and R=21.07 ± 0.14 mag/sq.arcsec, respectively (Skinakas Observatory, 2008)

Redani (2009) gave data about t Mount Gracham site, the place of the Large Binocular telescope. The zenith-corrected values of the NSB in UBVRI bands are 21.98, 22.81, 21.81, 20.82, and 19.78 mag/sq.arcsec, respectively.

Grankin (2009) reported that the NSB over and the Crimean Astrophysical Observatory in V band is 20.8 mag/sq.arcsec, respectively.

Conclusion

In the last 30 years the NSB over the Rozhen National Astronomical Observatory (NAO) in the Rhodope Mountains grows up obviously. The reason is the increase of the airglow from the nearby towns and villages. The main source of airglow is the developing winter mountain resort Pamporovo, with direct vicinity at 10-15 km from the Observatory.

This work confirm that the good astronomical site may be characterized with NSB in BVRI bands at least with 22.5, 21.5, 20.8 and 19.8 mag/sq.arcsec. From this point of view the Rozhen night sky is about 2.5 times brighter. The increasing of the Rozhen NSB in the period 1983-2003 is estimated to be about 0.4 mag or 1.4 times. So, the Rozhen NSB is relative high and this restricts the deep observations. In the same time the extinction of the clear Rozhen atmosphere in the beginning of the 20th remains relatively low, about 0.15 mag in B-band (Dimitrov, 2007).

References:

1. A f a n a s i e v, V. L., 1983, Private communication
2. B e n n, C. R.; E l l i s o n, S. L., 1998, New Astronomy Review 42, 503

3. C i n z a n o, F., 2000, Memorie della Società Astronomia Italiana, 71, 159
4. D i m i t r o v, D., 2007, Private communication
5. G a r s t a n g, R. H., 1989, Publ. Astron. Soc. Pacific 101, 306
6. G e o r g i e v, Ts. B., 2014, In preparation
7. G r a n k i n, K. N, 2009, http://astrotourist.info/analiz-zasvetki-v-krao
8. HyperLeda, 2014, http://atlas.obs-hp.fr/hyperleda/; http://www-obs.univ-lyon1.fr/hypercat
9. K r i s c i u n a s, K., 1997, Publ. Astron. Soc. Pacific 109,1181
10. K r i s c i u n a s, K., S e n l e r, D. L., R i c h a r d s, J., S c h w a r z, H. E., S u n t z e f f, N. B., V e r a, S., S a n h u e z a, P., l., 2007, PASP 119,687
11. NED, 2014, http://nedwww.ipac.caltech.edu
12. N e i z v e s t n y, S., 1982, Astropys. Invest. (USSR), 16, 49
13. P a n o v, K., 1984, Private communication
14. P a t a t, F., 2003, Astron. Astrophys. 400, 1183
15. R e d a n i, M., 200, Publ. Astron. Soc. Pacific 12, 778
16. R o c h, F. E., G o r d o n, J. L., 1973, *The light of the Night Sky,* Dordrecht, Reidel
17. Sánchez, S. F.; Aceituno, J.; Thiele, U.; Pérez-Ramírez, D.; Alves, J.,2007, Publ. Astron. Soc. Pacific 119,1186
18. Skinakas Observatory (2008), http://skinakas.physicsuc.gr
19. W a l k e r, M. F., 1970, PASP82, 682
http://www.lightpollution.it/dmsp/totbri.html