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# Astroclimate parameters of the Kyiv observatories

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Astroclimate parameters such as the atmospheric extinction, the night-sky brightness, and the seeing are studied using the observational data obtained at some Kyiv observatories. The first parameter is determined using the brief Bouguer method. The night-sky brightness is calculated using the images of standard stars in different filters. And the seeing is estimated basing on the FWHM of star profiles obtained during a set of observations at Kyiv observatories.

**Key words:** atmospheric effects, light pollution.

## INTRODUCTION

Ground-based astronomical observations are carried out through the entire atmosphere which is continuously moving and changing, that results in additional obstacles in obtaining high-quality data. The whole set of atmospheric conditions that affect astronomical measurements is called astroclimate. Astronomical observations conducted from the Earth surface require a number of clear nights, high atmosphere transparency and dark sky. The presence of some active astronomical observatories in Kyiv requires a constant monitoring of astroclimate parameters. Such activities are carried out in the majority of observatories [1, 2, 3].

## DATA AND DATA PROCESSING

To determine the extinction coefficient the data received in 2012 by A. Simon and V. Reshetnyk at Lisnyky observational station of the Astronomical Observatory of the Kyiv National Taras Shevchenko University at AZT-8 telescope were used. Images taken in 2009 by V. Reshetnyk with the Celestron CGE-1400 telescope at the Main Astronomical Observatory of the National Academy of Sciences of Ukraine (MAO NASU) were used for estimation of the night-sky background brightness and seeing values.

All the images were corrected for dark, flat field and bias. The special software was developed for fast image processing of the large data arrays. Its reliability was tested in comparison with the results of `MaxIm DL` and `IDL DAOPHOT`.

## ATMOSPHERIC EXTINCTION

We used the following formula of the brief Bouguer method to calculate the value of the atmospheric extinction:

$$\alpha(\lambda) = \frac{[m_A(\lambda) - m_B(\lambda)] - [m_A^0(\lambda) - m_B^0(\lambda)]}{[M(z_A) - M(z_B)]}, \quad (1)$$

where $\alpha(\lambda)$ is the extinction coefficient, $m_A(\lambda)$ and $m_B(\lambda)$ are the observed magnitudes, $m_A^0(\lambda)$ and $m_B^0(\lambda)$ are the magnitudes from a catalogue, $M(z_A)$ and $M(z_B)$ are airmasses.

Photometric data were obtained for the stars listed in Table 1. These stars are not photometric standards. Extinction coefficients were calculated for different filters. Results are given in Table 2.

Table 1: The list of observed stars.

| | |
|---|---|
| TYC 423 1203 1 | TYC 423 929 1 |
| USNO-A2.0 0900-10345260 | TYC 3507 2315 1 |
| USNO-A2.0 1350-09083719 | TYC 3507 2315 1 |
| USNO-A2.0 1350-10099071 | TYC 3553 232 1 |
| USNO-A2.0 0675-21954842 | TYC 6253 3197 1 |
| USNO-A2.0 0675-21937274 | TYC 3553 114 1 |

For one series of frames we calculated the extinction coefficients using different pairs of stars. Their errors were calculated as a standard deviation.

Table 2: Extintion coefficients.

| Filter | $\alpha$ | $\Delta$ |
|---|---|---|
| B | 0.55 | 0.05 |
| V | 0.35 | 0.10 |
| R | 0.42 | 0.32 |
| I | 0.36 | 0.07 |

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## NIGHT-SKY BRIGHTNESS

The identification of stars and the determination of scales were conducted using the calibrated images. Standard photometric stars in proper colour bands were found, using the `VizieR` Catalogue Service[1]. The instrumental magnitude of the stars and the sky background were obtained using the own developed software. The brightness of the sky was calculated using the Pogson formula:

$$m_{star} - m_{sky} = -2.5 \lg \frac{B_{star}}{B_{sky}}, \qquad (2)$$

where $m_{star}$ and $m_{sky}$ are the star and night-sky background magnitudes, $B_{star}$ and $B_{sky}$ are the star and night-sky brightnesses.

Using catalogues available via the `VizieR` Catalogue Service, we found apparent magnitudes of the identified stars in the U, B, V, R, I bands. Extinction was estimated using the following relation: $m(\lambda) - m_0(\lambda) = \alpha(\lambda) M(z)$. Extra-atmospheric magnitudes were taken from catalogues. Zenith distance was found for the series of frames in assumption that the temporal changes in results of observations are negligible and changes in the angle can be neglected.

The values of the night-sky background, $m_{sky}$, in mag arcsec$^{-2}$ and their errors are given in Table 3. Errors of U-magnitudes could not be estimated because of the lack of reliable data. Errors were obtained using the following relation:

$$\Delta m_{sky} = \sqrt{\left(2.5 \frac{\Delta B_{star}}{B_{star} \ln 10}\right)^2 + \left(2.5 \frac{\Delta B_{sky}}{B_{sky} \ln 10}\right)^2}.$$

Table 3: Night-sky background brightness.

| | U | B | V | R | I |
|---|---|---|---|---|---|
| $m_{sky}$ | 18.2 | 18.86 | 18.10 | 17.94 | 17.69 |
| $\Delta m_{sky}$ | — | 0.08 | 0.02 | 0.01 | 0.76 |

## SEEING

The seeing was estimated quantitatively from the analysis of the averaged star profile using the FWHM in the `IDL` image processing procedures. 2D and 3D averaged profiles of stars were built in 10×10 pixel areas around the central stars extracted from the original images (Fig. 1).

Then the star profiles were fitted using the Gaussian function with the following formula:

$$F(x, y) = A_0 + A_1 e^{-U/2}, \qquad (3)$$

where $U = (x/a)^2 + (y/b)^2$. Here $x$ and $y$ are horizontal and vertical dimensions (conventionally). The results for FWHM and their errors are given in Table 4. Errors were calculated as standard deviations.

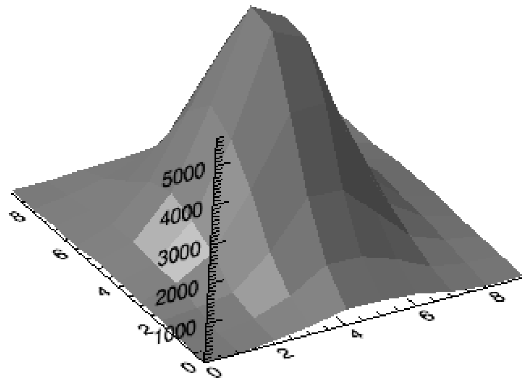


Fig. 1: Three-dimensional star profile. Dimensions of stars are given along the both horizontal axes and the relative flux is given along the vertical one.

Table 4: Value of FWHM parameter.

| Time (JD) | FWHM | ΔFWHM |
|---|---|---|
| 2454838.2556 | 3.63 | 0.75 |
| 2454843.2261 | 4.44 | 0.85 |
| 2454843.2524 | 3.5 | 1.3 |
| 2454885.2896 | 3.34 | 0.14 |
| 2454885.3171 | 2.76 | 0.06 |
| 2454885.3297 | 3.26 | 0.04 |
| 2454885.3931 | 3.01 | 0.08 |
| 2454885.4200 | 3.0 | 1.7 |
| 2454885.4347 | 2.44 | 0.15 |
| 2455408.3053 | 2.79 | 0.15 |
| 2455408.4178 | 2.91 | 0.25 |
| 2455415.3056 | 2.76 | 0.81 |

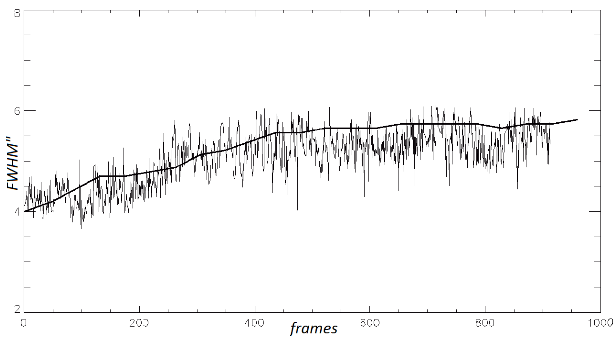


Fig. 2: FWHM parameter changes for the series of images.

FWHM change graph which is an intermediate result for series of frames obtained on 01.06.2009 is

[1] `http://vizier.u-strasbg.fr/viz-bin/VizieR`

shown in Fig. 2. Here the bold line is the curve of the temperature changes. The correlation coefficient is 0.94, that can be explained by telescope defocusing caused by ambient temperature changes.

## RESULTS AND CONCLUSIONS

The estimations of the extinction coefficient were obtained using the brief Bouguer method. The obtained results for observational night were conformed with the values for middle latitudes observatories. The value of the night-sky brightness indicates a significant illumination from the Kyiv city. The obtained seeing cannot compete with seeing from highland observatories but its values are good enough to to meet the requirements of the scientific studies.

## ACKNOWLEDGEMENT

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