S E S   2 0 1 0
Sixth Scientific Conference with International Participation
SPACE, ECOLOGY, SAFETY
2–4 November 2010, Sofia, Bulgaria

METHODS FOR PHOTOMETRIC RESEARCH OF THE EFFICIENCY OF ELECTRONIC-OPTICAL DEVICES AT DIFFERENT BACKGROUND BRIGHTNESS

Stiliyan Stoyanov

Space and Solar-Terrestrial Research Institute – Bulgarian Academy of Sciences
e-mail: stil717@yahoo.com

Key words: *photometric research, electro-optical devices*

Abstract: *The paper presents a detailed method for photometric calculation of the efficiency of electro-optical devices at different background brightness, based on theoretical research and conducted experiments.*
Using the developed method, experimental tests have been carried out and the obtained results have been presented.

МЕТОДИКА ЗА ФОТОМЕТРИЧНО ИЗСЛЕДВАНЕ НА ЕФЕКТИВНОСТТА НА ЕЛЕКТРОННО-ОПТИЧЕН УРЕД ПРИ РАЗЛИЧНА ЯРКОСТ НА ФОНА

Стилиян Стоянов

Институт за космически и слънчево-земни изследвания – Българска академия на науките
e-mail: stil717@yahoo.com

Ключови думи: *фотометрично изследване, електронно-оптични уреди*

Резюме: *В представения труд е разработена подробна методика за фотометрично пресмятане на ефективността на електронно-оптични уреди при различна яркост на фона, разработена на базата на теоретични изследвания и проведени експерименти.*
С използване на разработената методика са проведени експериментални изследвания и са представени получените резултати.

The basic of the methods is to research the upmost sensitivity at assigned parameters. The value which characterizes the device's sensitivity is presented the upmost power illumination of the entrance hole with the relation signal/noise or the upmost value of the current, radiated by the object when the level of the noises is set.

The method of the energy research of the electronic-optical devices has some important specifications in comparison with the method of the optical and optical-electronic devices. Because the electronic-optical devices comprises of optical, photo-electronic, electro-technical and luminescent devices, so it is necessary to use different methods for research and coordinate the characteristics of the indicated devices when their parameters are defined. For each of the methods, it is necessary to take into account the volume and the character of the necessary information for the researched object and this information helps to find the object, to define its boundaries and to ensure the detailed research of its structure. Depending on these circumstances, not only the range of the researched objects is changed but also the sequence of the stages of the energy calculations. [1…3].

When finding distant objects, it is necessary to specify the following circumstances:

- Upmost contrast brightness of the observer's pupil;
- светотехнични characteristics of the researched object;
- taking into considerations the atmospheric influence;
- research of the utmost illumination of the photocathode from the hypothetical illumination from the object and the background around it;
- Comparison of the obtained results with the utmost contrast sensitivity of the eye at given observation conditions.

In order to define the efficiency of the electronic-optical devices, a method is suggested which was developed on the basis of theoretical research and experimentations, carried out by the author and it ensures the research of the possibility to find distant objects at different background brightness.

1. Determination of the effective energetic illumination of the photocathode image $E_{ef_{fk}}$:

(1)

$$E_{ef_{fk}} = \frac{A_{ob}}{\pi \Gamma^2 L^2} \int_{\lambda_0}^{\lambda_k} (\sqrt{\lambda} + \rho_\lambda e_\lambda) \tau_{\lambda_f} \tau_{\lambda_{op}} \tau_{\lambda_{atm}} d\lambda ,$$

where:
- A_{ob} – surface of the entrance hole of the lens;
- Γ – magnification of the optical system;
- e_λ – energetic illumination of the entrance hole;
- L – distance of observation;
- $\lambda_0 ... \lambda\kappa$ – spectral range of the research;
- ρ_λ – spectral coefficient of the reflected filters;
- τ_{λ_f} – spectral percolation of the attached filters;
- $\tau_{\lambda_{op}}$ – spectral percolation of the optical system;
- $\tau_{\lambda_{atm}}$ – spectral percolation of the atmosphere.

2. Definition of the influence of outside noise fluctuations over the image brightness is done by using the coefficient $K_{sch\,i}$, defining the image sharpness

(2)

$$K_{sch_i} = \frac{1}{2N_{fk}} \sqrt{\frac{t}{2\lambda} S_{\lambda_{\max}} E_{ef_{fk}}} ,$$

where:
- N_{fk} – quantum exit of the photocathode;
- t – time of the experiment;
- S_λ – spectral sensitivity of the photocathode.

3. Defining the coefficient which characterizes the relationship signal/noise for the background current K_{sch_t} :

(3)

$$K_{sch_t} = \frac{E_{ef_{fk}} S_{\lambda_{\max}}}{J_t} ,$$

where:
- J_t – background current of the photocathode;
- $S_{\lambda_{\max}}$ – maximum spectral sensitivity of the photocathode.

4. Definition of the relationship signal/noise, considering the noises from the amplification of the information signal from the electronic-optical transformer and background current

(4)

$$K_{sch} = \frac{E_{ef_{fk}} S_{\lambda_{\max}} \sqrt{t}}{\sqrt{4 e_\lambda N_{fk}^2 E_{ef_{fk}} S_{\lambda_{\max}} + J_t^2}} .$$

5. Definition of the brightness background B' at the entrance of the electronic-optical device:

(5)

$$B' = K_{sch} \left(\frac{\tau_{\lambda_{op}} K_d^2 K_b}{4 \Gamma_{EOP}^2} \right) \left(\frac{D}{f'_{ob}} \right),$$

where:
- K_d – coefficient, considering the Styles-Crawford effect;
- K_b – coefficient, considering not using the full usage of the eye's pupil;
- Γ_{EOP} – optical magnification of the electronic-optic transformer;
- D – diameter of the entrance hole;
- f' – back focal distance of the lens.

6. Defining the diameter of the observer's pupil and the coefficients K_d and K_b for B'.
7. Defining the exponent n and n' for B and B' respectively.
8. Defining the efficient illumination $E_{ef_{fk}}$ of the object over the photocathode:

(6)
$$E_{ef_{fk}} = \frac{2e_\lambda N_{fk}^2 K_{sch} + K_{sch}\sqrt{4e^2 N_{fk}^4 + J_t^2 t}}{tS_{\lambda_{\max}}}.$$

9. Defining the efficient illumination of the background image over the photocathode:

(7)
$$E_{ef_{fk\ fon}} = \frac{A_{ob}R_{ef}}{nA_{fk}},$$

where: R_{ef} – energetic illumination of the object;

A_{fk} – surface of the photocathode of the electronic-optic transformer.

10. Defining of the sharpness of the image K:

(8)
$$K = \frac{E_{ef_{fk_{ob}}} + E_{ef_{fk_{fon}}}}{E_{ef_{fk_{ob}}} - E_{ef_{fk_{fon}}}}.$$

11. Defining of the utmost sharpness K' of the image:

(9)
$$K' = \frac{1+K}{1-K}.$$

12. Defining the efficiency N_{EOV} of the electronic-optical device:

(10)
$$N_{EOV} = \frac{K'A_{ob}(D^2 tK_d^2 K_b)^{1-n'}(\Gamma_{EOP} f'_{ob})^{2n'}}{o{,}25^n 4(f'_{ob})^2},$$

where: n – exponent, characterizing the influence of the background brightness [2,4].

13. Defining the utmost illumination E_{EOV} of the device:

(11)
$$E_{EOV} = E_H \,/\, N_{OEV},$$

where: E_H – observed utmost illumination with the naked eye.

Using the worked out method, experimental research was being carried out with an electronic-optical device. Table 1 represents the obtained results.

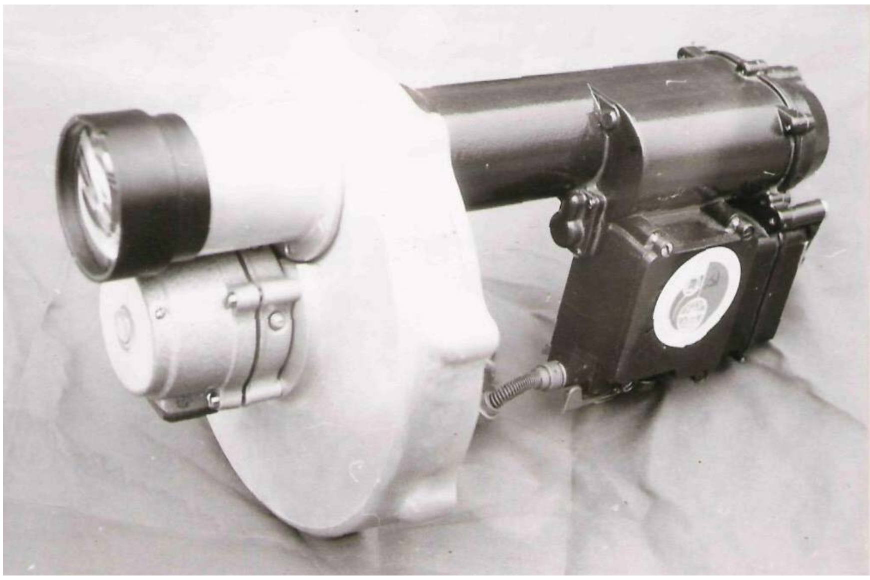

Fig. Electronic-optic device for research of particular emissions of the atmosphere in the near infrared part of the optical spectrum

Table 1. Photometric characteristics of the electronic-optic device

№	Characteristics	Background brightness [*cd/m*²]	
		$B = 1.10^{-5}$	$B = 1.10^{-3}$
1	$E_{ef_{fk}}$	5,88	5,88
2	K_{sch_i}	0,12	0,12
3	K_{sch_t}	0,02	0,04
4	K_{sch}	0,19	0,19
5	B'	$7{,}7.10^{-6}$	$7{,}8.10^{-2}$
6	K_d	1	1
7	K_b	1	1
8	n	0	0,24
9	n'	0	0,53
10	E_H	10^{-8}	10^{-7}
11	K'	1,45	1,56
12	N_{OEV}	44	44
13	E_{EOV}	$2{,}75.10^{-11}$	$4{,}07.10^{-9}$

It can be concluded that a detailed method is developed which ensures photometric research of the efficiency of the electronic-optic device at different background brightness.
The method is used when calculating the electronic-optical device for research of particular emissions in the atmosphere in the near infrared part of the optical specter.

References:

1. Ж е к о в, Ж. Оптични системи за наблюдение на отдалечени обекти. Издателство Шуменски университет „Епископ К. Преславски”, Шумен, 2007, 251 с.
2. Ж е к о в, Ж, И. Х р и с т о в, Г. М а р д и р о с я н, С. С т о я н о в. Оценка пространствените и енергетични параметри на оптични уреди. Сб. доклади „40 години от първия полет на човек в Космоса”, ВВВУ, Долна Митрополия, 2001, с. 329-334.
3. М а р д и р о с я н, Г. Аерокосмически методи в екологията и изучаването на околната среда. Акад. Издат. „Проф. Марин Дринов”, София, 2003, 208 с.
4. С т о я н о в, С. Приложна оптика. Издат. „Фабер”, Велико Търново, 2009, 234 с.