S E N S 2 0 0 7
Third Scientific Conference with International Participation
SPACE, ECOLOGY, NANOTECHNOLOGY, SAFETY
27–29 June 2007, Varna, Bulgaria

INFLUENCE OF THE TURBULENCE OF ATMOSPHERE DURIG OPTIC MEASUREMENTS

Stiliyan Stoyanov[1], Valya Dimitrova[2], Angel Manev[3], Kunyu Palazov[3]

[1]Space Research Institute - Bulgarian Academy of Sciences
[2]Sofia University "St. St. Kliment Ohridski"
[3]Central Laboratory of Solar-Terrestrial Influences - Bulgarian Academy of Sciences
e-mail: stil@yahoo.com

ВЛИЯНИЕ НА ТУРБОЛЕНТНОСТТА НА АТМОСФЕРАТА ПРИ ОПТИЧНИ ИЗМЕРВАНИЯ

Стилиян Стоянов[1], Валя Димитрова[2], Ангел Манев[3], Куню Палазов[3]

Key words: *turbulence, atmosphere, optic measurements*

Ключови думи: *турболенция, атмосфера, оптични измервания*

Abstract: *Turbulent phenomena in the atmosphere, which lead to fluctuation of the intensity of the optical signal, are the cause for additional errors in optical and electronic goniometric devices. A quantitative evaluation of these errors is presented in this paper.*

Different goniometric devices are used in optical and electronic devices for targeting, chasing and control. These goniometric devices consist mainly of coordinate sensitive photo receiver and optical receiving system that converts the angular coordinates into linear. Regardless of the photo receiver type, the signal coming from the object through the use of the optical system is focused on no more than two elements of the photo receiver. The difference in the signals of the two elements is proportional to the angular coordinate, and the beginning of the report coincides with the direction of the optical axis.

When using the devices in the conditions of the ground level atmosphere, the value of the intensity of the incoming optical signal fluctuates, as a result of the turbulent phenomena in the atmosphere.

An operation of division of the difference in signals and their sum is undertaken in order to exclude the effect of the atmospheric turbulence and other factors influencing the absolute value of the signal of the photo receivers. [1].

$$\varphi = k\frac{U_1 - U_2}{U_1 + U_2},$$

where: φ – angular coordinate;
k – coefficient of proportionality;
U_1 and U_2 – value of the signal at the output of the photo receivers.

If we assume the probability, that the tension of the noises at the output of two photo receivers is distributed according to a normal law, the noises the two photo receivers are not correlated and they have equal dispersion and do not depend on the value of the signal U', and when we have $\frac{U^{I}}{U^{II}} = \rho >> 1$, the average quadratic value of the error of optical and electronic goniometer $\Delta\varphi$ could be expressed as follows:

(1) $$\Delta\varphi = k\frac{\sqrt{2}U^{II}}{U^{I}} = \frac{k\sqrt{2}}{\rho},$$

where: U'' - average quadratic value of the tension of the noises at the output of every photo receiver;

$$U' = U_1 + U_2\ .$$

As long as U' fluctuates because of the turbulent phenomena in the atmosphere, from (1) follows that $\Delta\varphi$ also fluctuates, i.e. every moment the value of U' corresponds to a certain value of $\Delta\varphi$. With time for measuring t, significantly exceeding the time for correlation of the fluctuating process $\tau(t >> \tau)$, the value of the error $\Delta\varphi$ is being averaged according to the value of the incoming signal:

$$\overline{\Delta\varphi} = \int_0^\infty \Delta\varphi(U')\omega(U')dU',$$

where: $\varpi(U')$ – density of the probability of the value U'

Assuming that the density of the probability of the value U' is distributed logarithmically according a normal law [2] i.e.

(2)
$$\omega(U') = \frac{1}{\sqrt{2\pi}\sigma U'} e^{\frac{-\left(\ln\frac{U'}{U_0} - \mu\right)^2}{2\sigma^2}}$$

where: $\mu = \overline{\ln\frac{U'}{U_0}}$;

$$\sigma^2 = \overline{\left(\ln\frac{U'}{U_0} - \mu\right)^2};$$

U_0 – Constructional coefficient,

Thus:

$$\overline{\Delta\varphi} = \int_0^\infty \frac{kU''}{\sqrt{\pi}\sigma U'^2} e^{\frac{-\left(\ln\frac{U'}{U_0} - \mu\right)^2}{2\sigma^2}} dU' \quad (3)$$

Transforming the formulae (3) we have:

(4)
$$\overline{\Delta\varphi} = k\sqrt{2}\frac{U''}{U_0} e^{-\overline{\ln\left(\frac{U'U''}{U_0}\right)} + \frac{\sigma^2}{2}} = k\sqrt{2}.e^{-\overline{\ln\rho} + \frac{\sigma^2}{2}}$$

From formulae (4) comes the conclusion that the value $\overline{\Delta\varphi}$ did not depend on the choice of U_0

The average value of the error is a function of the level of the incoming signal and the value of the additive and multipliable disorders.

Investigating the formulae (4) we observe that $\overline{\Delta\varphi}$ quickly increases its value with the increase of σ.

For measuring time t, much smaller than the time for correlation of the fluctuating process $\tau(t >> \tau)$, there is a probability that the value of the error exceeds certain admissible value. $\Delta\varphi'(P(\Delta\varphi \geq \Delta\varphi')$

In order to calculate the probability, it is reported that:

$$P(\Delta\varphi \geq \Delta\varphi') = P(U' \leq U'_{\min})$$

where: $U'_{\min}$ - is calculated with the formulae:

$$U'_{\min} = k\sqrt{2\frac{U''}{\Delta\varphi'}}\ .$$

Then:

(5) $$P(\Delta\varphi \geq \Delta\varphi') = \int_0^{U'_{\min}} \omega(U')dU'$$

After substituting formula (2) in formula (5) we have:

$$P(\Delta\varphi \geq \Delta\varphi') = F\left(\frac{\ln\frac{U'_{\min}}{U_0} - \mu}{\sigma}\right) = F\left(\frac{\ln\frac{k\sqrt{2}}{\Delta\varphi'} - \overline{\ln\rho}}{\sigma}\right)$$

where: $$F = \int_0^{\infty} \frac{1}{\sqrt{2\pi}} e^{-\frac{t^2}{2}} dt.$$

In conclusion we could summarize:

1. The value $P(\Delta\varphi \geq \Delta\varphi')$ did not depend on the choice of U_0 and is a function from the level of the incoming signal and the value of the additive and multipliable noises.
2. The turbulent phenomena in the atmosphere, leading to multipliable noises, have a great influence for causing errors in optical and electronic goniometer. The report for these errors is necessary in the process of creating devices, which are designed to be used in the atmospheric ground levels.

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