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STATISTICAL PROPERTIES OF THE BACKGROUND NOISE FOR THE ATMOSPHERIC WINDOWS IN THE INTERMEDIATE INFRARED REGION

O. P. KUZNECHIK
Observatory BSU, Fr. Skariny av. 4, 220050 Minsk, Belarussia

Abstract. The statistical properties of the clear sky noise for three atmospheric windows in the infrared spectral region 1.8 - 5.2 μm were analysed. The modified statistical model for the background noise was derived.

1. INTRODUCTION

The background noise consists of the spatial radiance fluctuations of the radiative scattering, reflection, or emission due to the bodies other then targets sought by the systems.The statistical theory of the background noise has been developed by the authors (Jones, 1955; Free, 1959; Robinson, 1959; Aroyan, 1959; Jamieson, 1961; Eldering, 1961; Takagi et al., 1968; Kuznechik et al., 1972), analogous to the theory of the noise applied to the communication system. Then it has been pointed out by the authors (Takagi et al., 1968; Kuznechik et al., 1972) that statistical model of the background noise might be regarded as a random set of two - dimensional pulses whose amplitudes and widths obey the Gaussian and Poisson's distribution rule, respectively. Later the unified statistical model for the background noise including the whole intermediate infrared spectral region was derived (Itakura et al., 1974; Kuznechik, 1979,1982). Its validity was confirmed with some experimental results. We propose to modify the calculation scheme by including structural function as a intermediate element. It gives the posibilites: to improve the accuracy of the calculations, to make the model more realistic and to expand the class of background noises, which may be described by this model.

2. THEORY

We assume that the background noise process may be a random set of the two - dimensional pulse whose amplitude and width obey the Gaussian and Poisson's statistics, respectively, as follows;

$$P(L) = (2\pi\sigma^2)^{-0.5} \exp[-(L - \bar{L})^2 (2\sigma^2)^{-1}], \qquad (1)$$

$$P(r) = \alpha \exp(-\alpha r), \qquad (2)$$

where L is the radiance of the certain point on x - y plane, L is the mean value of L, σ^2 is the variance of L , r is the interval length between two adjacent points on x - y plane, α is the average invers pulse width.

If the random processes L and r are independent of each other, then the two - dimensional structural function, and the two - dimensional autocorrelation function can be expressed as

$$D(\Delta) = \langle [L(x+\xi, y+\eta) - L(x, y)]^2 \rangle, \qquad (3)$$

$$R(\Delta) = \sigma^2 - 0.5\, D(\Delta), \qquad (4)$$

$$R(\Delta) = \bar{L}^2 P(\Delta) + \bar{L}^2 [1 - P(\Delta)] = \sigma^2 \exp(-\alpha\Delta) + \bar{L}^2, \qquad (5)$$

where ξ is the interval length between two adjacent points on x coordinate, η is the interval length between two adjacent points on y coordinate, $P(\Delta)$ is the probability that two adjacent points on x - y plane, whose interval length is Δ, belong into the same pulse.
It follows from (2) $P(\Delta)$ is given by

$$P(\Delta) = \int_0^\infty (1 - \Delta \cdot r^{-1})\, P(r)\, dr = \exp(-\alpha\Delta). \qquad (6)$$

Taking Fourier transform of $R(\Delta)$, the two - dimensional Wiener spectral density function $W(w_x, w_y)$ is obtained, as follows;

$$W(w_x, w_y) = 2\pi\alpha\sigma^2 (\alpha^2 + w_x^2 + w_y^2)^{-1.5}, \qquad (7)$$

provided that $\bar{L} = 0$, and w_x, w_y are the x and y components of the spatial frequency, respectively.
In practice, the measurement of the background noise is made with the scanning radiometer, so that we can only obtain the one - dimensional Wiener spectrum of the spatial frequency associated with the scanned spatial coordinate. The one - dimensional Wiener spectral density function is given by

$$W(w) = 4\alpha\sigma^2 (\alpha^2 + w^2)^{-1}. \qquad (8)$$

It should be remarked that the characteristic of the Wiener spectrum W(w), which is inversely proportional to the spatial frequency squared, depends on the average invers pulse width.

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