ESTIMATION SCINTILLATION INDEX ON A SUPERCONDUCTOR RECEIVER FOR GAUSSIAN LASER BEAM PROPAGATED TROUGH RANDOM PHASE SCREEN

N. Kh. Gomidze[1,a], I. N.Jabnidze[1,b], K.A.Makharadze[1,c], M.R.Khajishvili[1,d], L.G.Kalandadze[1,e], O.Nakashidze[1,f], E.N.Mskhaladze[2,g]

[1] *Batumi Shota Rustaveli State University, Batumi, Georgia*
[2] *Batumi Maritime Academy*
[a]gomidze@bsu.edu.ge, [b]izolda.jabnidze@bsu.edu.ge, [c]k.makharadze.01@gmail.com, [d]mirandukht@gmail.com, [e]lali.kalandadze@bsu.edu.ge, [f]omar.nakashidze@bsu.edu.ge, [g]eldar@mskhaladze.com

Abstract: The goal of the present work is to study the regulations of the changes of the characteristics of high frequency optical signals using both quantitative and qualitative terms, on the basis of changes statistical parameters of turbulent media on the random phase screen model. There is an analytical assessment of statistical moments of laser radiation via random phase screen by numerical modelling and comparison with known experimental results. The object of the study is a random inhomogeneous atmosphere with weak turbulence, as well as optically dense turbulent media. The model of a random phase screen is discussed and the distribution of the statistical moments of scattered laser radiation is studied. The dependence of the effective size of the laser beam and the scintillation index on the correlation radius of the phase screen in the plane of the detector for a random phase screen is estimated.

1. Introduction

In this paper, we will, based on the Rytov weak fluctuation method [1] and the thin phase screen model [2], research the statistical property of Gaussian beam propagation through an arbitrary thickness phase screen [3], establish the mathematic models of involving statistical quantities, and develop the analytical results. The application scope of our results will be discussed based on the comparison between the thin phase screen models and arbitrary thickness models.

2. Formulation of the problem

The case when the laser beam incident perpendicularly to the phase screen was studded in the work [4]. The phase screen is of a small thickness, scattered radiation is registered in the distant zone through the photo detector. The photo detector axis makes θ angle of the laser beam (fig. 1). Let's consider the case when phase screen model is with arbitrary thickness. Optical system detects the signal passing through a random phase screen (fig.2).

If it is known the statistics of deterministic coherent Gaussian laser beams, it is possible to calculate the scintillation index on the detector plane on the basis of averaging over the ensemble of intensity incident on the detector partially coherent beam.

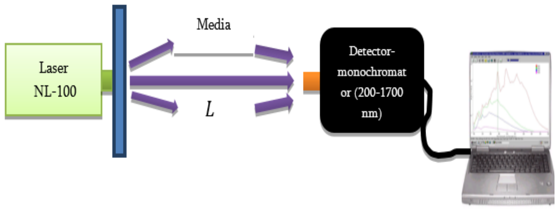

Fig 1. An experimental device scheme for studying partially coherent laser beam in the free space or in the turbulent media

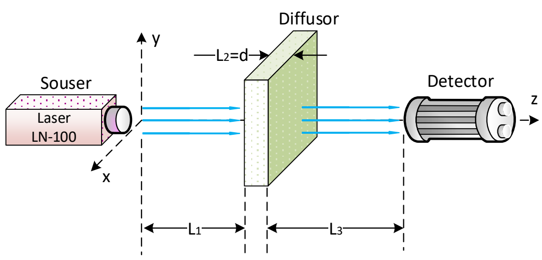

Fig.2. Propagation of a laser beam located at a distance L_1 from the optically dense medium (diffuser) with the arbitrary thick $L_2 = d$ to the detector (optical system) located at a distance L_3 from the diffuser.

3. Results of numerical experiments

The dependence of the effective normal radius $W_{1,d}/W_0$ ($W_0 = 2.5$ cm) of the laser beam on the correlation radius l_c via diffuser is shown on the Fig. 3. Fig.4 provides an effective scintillation index as the function of the correlation radius for different length from diffusor ($L = 200$ m – red line, $L = 500$ m – green line). Fig.5 shows impact of the detector area on the fluctuation intensity spectrum and on the Doppler spectrum for the Gaussian laser beam.

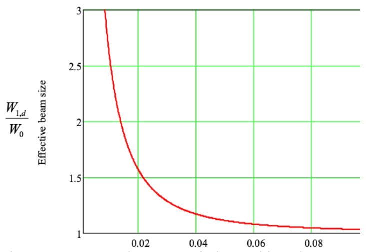

Fig.3. Dependence of the effective normal radius W_d/W_0 vs correlation radius l_c, when: $W_0 = 2.5$ cm, $L = 500$ m.

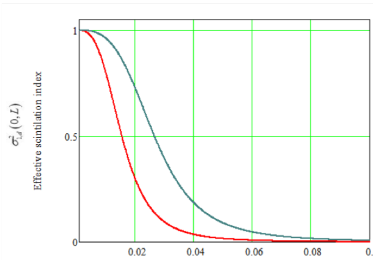

Fig.4. Effective scintillation index vs correlation radius l_c, for different distant from diffusor ($L = 200$ m – red line, $L = 500$ m – green line), when: $W_0 = 2.5$ cm.

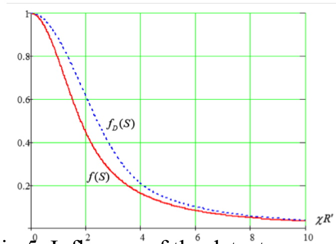

Fig.5. Influence of the detector surface on the intensity spectrum of the fluctuation $f(S)$ (dot line) and on the Doppler's spectrum $f_D(S)$ (line) for the Gaussian laser beam.

Conclusion

- The effective function of mutual coherence, consequently, the laser beam size, intensity, correlation radius and the expressions of the angle of fluctuations are obtained in the plane of the detector. It is shown that the laser beam size, the correlation radius and the average intensity of the radiation coincide with the results of Riklin's or other's works. However, the results obtained in the turbulence of the atmosphere somewhat differ from the classical results. The results obtained for the coherence radius are in good standing with the results obtained in Belenk's and other's works.
- In case of fast detectors, the scintillation index is obtained in the free space of laser beam, as well as in the weak turbulence atmosphere. In case of a strong diffuser, the model shows that the index is close to 1 and agrees with Akhmanov's and other's works. While considering the atmospheric effects, the influence of diffuser on the effect of scintillation in the receiving detector space is in compliance with the results obtained in Andrius' and other's works.
- The correlation function of the intensity is calculated which shows that the doppler spectrum dominance in the expression of the correlation function of intensity increases the value of the signal/noise ratio to the detector's outlet.

Acknowledgment

2019 Competition for Targeted Scientific Research Projects "Diagnostics of a liquid medium based on an estimate of the correlation function of the intensity of partially coherent waves scattered from the fluid volume". Batumi Shota Rustaveli State University (2019), project manager PhD of Physics Kakha Makharadze.

References

[1] Bernhardt, P., et al., "Ionospheric applications of the scintillation and tomography receiver in space mission when used with the DORIS radio beacon network," J. Geod, 80, 2006.

[2] Andrews L. C., Phillips R. C., Hopen C. Y. Laser beam scintillation with applications (SPIE Opt. Eng. Press, 2003).

[3] Tian Y., Guo J., Wang R., Wang T. Mathematic model analysis of Gaussian beam propagation through an arbitrary thickness random phase screen. Optics Express, vol. 19, no. 19, 2011

[4] Gomidze N. Kh, Khajisvili M. R., Jabnidze I. N., Makharadze K. A., Surmanidze Z. J. To the Problems of Detecting Signals Passing Through a Random Phase Screen. Journal "Recent Advances in Technology Research and Education" Springer International Publishing. Print ISBN: 978-3-319-99833-6, Electronic ISBN: 978-3-319-99834-3, pp. 177-184, 2018.