DIFFUSE PATH REFLECTOR

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A reflector with a diffuse scatterer at the lens focus has been described. The informational characteristics of atmospheric channel including the reflector have been given. The parameters of the reflector have been analyzed together with possible fields of its application.

Retroreflectors of different types[1,2] (light returning devices) such as corner–cubes, diffuse scattering screens of "cat eye" type, etc. are applied to the measurement of the atmospheric optical characteristics, sounding of the atmospheric turbulence, and in systems of data processing and transfer. The properties of reflectors and expediency of applying one or another type of light returning device are determined by the character of a problem.[2] The reflector of lens type with a diffuse scatterer in the focal plane of the lens is described in this paper.

The instantaneous distribution of the intensity of radiation scattered in a randomly inhomogeneous medium at a distance L from a receiving–transmitting system is determined by the parameters of a propagation medium and reflector as well as by the parameters of beams and optical systems.[2–4] In order to decrease the influence of turbulent inhomogeneities on the parameters of received radiation and on the informational characteristics of channel as a whole, different modifications of reflecting systems are used. For example, a light returning device was proposed in Refs. 1 and 4 in the form of a strip or an array of corner–cube reflectors.

In the case of a lens reflector, a diffuse scatterer placed at the lens focus is analogous to diffuse source of partially coherent radiation. The beam parameters averaged over the beam cross section are determined in the geometric optics approximation as the parameters of a projecting–illuminating systems.[5]

The large–scale inhomogeneities lead to the shift of a beam as a whole, to the change of the diffuse source position in the focal plane, as well as to the change of the source size due to re–focusing caused by average bending of the wave front of the beam.

An analysis of the mean intensity distribution at the output of a spherical lens reflector of "scotch light" type (applied as a light returning device on roads) has been carried out in Ref. 6 taking into account the diffuse component. The results of Ref. 6 are compared with the parameters of a diffuse lens reflector in Fig. 1, where the densitograms show the intensity distribution over the cross section of a reflected beam $J(r, \alpha)$ for the refractive index n being equal to 1.5 (curve *1*) and 1.53 (curve *2*), and curves *3* and *4* show $J(r, \alpha)$ of the diffuse lens reflector (the radiation wavelength is $\lambda = 0.63$ μm) with the focal length $f = 24$ cm, lens diameter $D = 12$ cm, and the refocusing–parameter $M = l/f$, where l is the amount of the scatterer displacement from the focal plane, being equal to 0.01 and 0.1, respectively. Curve 5 is for $J(r, \alpha)$ of a diffuse source in the form of a set of chaotically mixed multimodal light guides that produce the radiation field as superposition of a large number (~10^4) of spatial modes, analogously to the "generalized Mikaelyan lens".[7] Here α and $2r$ are the angular and spatial coordinates, respectively, counted off from the point of intersection of the principal optical axis with the lens surface.

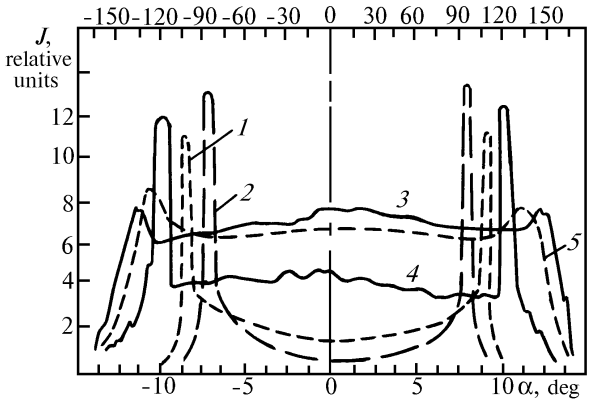

FIG. 1. Densitograms of the intensity distribution $J(r, \alpha)$ over the cross section of a reflected beam.

The size of spots of the specle–pattern in the lens plane

$$a_s \approx x/ka_0 \qquad (1)$$

(a_0 is the size of the illuminated area of the scatterer, x is the distance from the scatterer to the lens, i.e., for moderate turbulence and large $N = 2f/D$, $x = f$, where k is the wave number[2]) for commonly used reflector size (~10 cm) is ~10^{-3} m, i.e., the size of coherent zones in the beam propagating from a reflector to receiver is within the range of the characteristic size of the inner turbulence scale l_0 and even smaller.[2,3] The spot size in the receiving–transmitting system plane a_L is approximately equal to a_s (see Refs. 2 and 3). Thus, the total field of the reflected radiation consists of coherent and incoherent components with different characteristic spatial size, so the interaction with atmospheric inhomogeneities is different for each component. It is of interest, for example, for measurements of displacement of the energy centers of coherent and diffuse components for large–scale inhomogeneities. The properties of systems using beams with partial spatial coherence have been considered in a number of papers,[1,3,8–10] so the diffuse reflector is of interest as an element of optical measuring and informational systems. Since the characteristic size of the spot structure in the receiving plane is less than the size of commonly used apertures, taking into account the dependence of photodetector current fluctuations and signal–to–noise ratio[1,2] on a_L/d one would expect the change of informational characteristics of the channel with diffuse lens reflector.

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The above–described reflector was used to determine the informational characteristics of atmospheric channel with binary signal transfer.[1] The comparative stability of the channel against noise was investigated, i.e., the total probability of the error $P_{er} = P_1 + P_0$, where P_1 is the probability of false reception of "1" and P_0 is the probability of false reception of "0" for different values of the turbulence parameter C_n^2 measured by the technique of determining the half–width of the radiation spot in the objective focal plane for radiation that has passed once through the atmosphere[8] at $\lambda = 0.63$ μm. The height of the measurement path was $h = 10$ m, the path length was $L = 950$ m. The FD–7G photodiodes placed near the collimated output (d = 2.5 cm) of a Nd^{3+}:YAG laser operating at $\lambda = 0.53$ μm with a pulse repetition frequency of 25 Hz and a pulse duration of 15 ns were used as photodetectors. The size of the sensitive element of photodiode was 2.5 mm, the receiver field of view was approximately 1 rad. All measurements were carried out in the morning and daytime under condition of significant background level. A diffuse reflector was a lens with the diameter $D = 60$ cm and the focal length $f = 150$ cm, a ceramic beard of an imaging device was used as a scatterer.

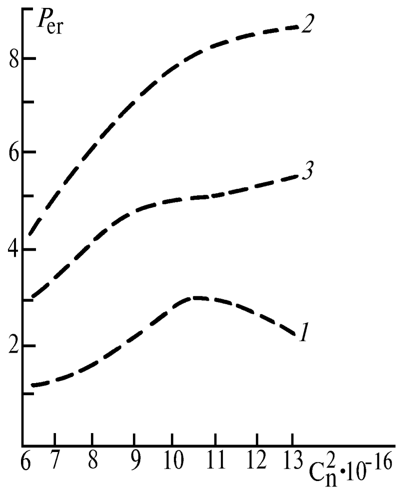

FIG. 2. Total probability of the error as a function of $P_{er}(C_n^2)$.

Figure 2 shows the dependence of P_{er} on C_n^2 (curve *1*) in the channel with diffuse reflector, of P_{er} on C_n^2 for the reflector with a mirror at the lens focus (curve *2*), and of P_{er} on C_n^2 (curve *3*) for nonlinear mirror harnessing the Mandel'shtam–Brillouin stimulated scattering (MBSS), which takes place within a cell filled with a nonlinear phase–conjugating medium (nitrobenzene) placed in the focal plane of the reflector lens, for the phase conjugation.[11] It is seen that the dependence of P_{er} on C_n^2 saturates at a level of C_n^2 (max) of the order of 10^{-15} cm$^{-3/2}$. In this case, the dependence of P_{er} on the turbulence intensity qualitatively follows the behavior of the variance σ of the radiation intensity fluctuations as the turbulence intensity increases for saturated amplitude fluctuations.[2,3]

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