Experimental investigation into the effect of detector field of view on the variance of laser beam fluctuations in snowfalls (0.63 μm)

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The variance of beam fluctuations has been studied as a function of receiver field of view γ for wide collimated and divergent beams in snowfalls. It has been found that as γ varies from $0.9 \cdot 10^{-3}$ to 0.6 rad, the measured variance is independent of the receiver field of view.

The average level of the received laser signal as a function of the receiver field of view in snowfall was studied earlier in Ref. 1. This characteristic first grows and then saturates as the receiver field of view increases from $0.8 \cdot 10^{-3}$ to $4.4 \cdot 10^{-3}$ rad. The average value of the signal in saturation mode increases with the increase of the meteorological visibility range.

The variance of laser beam fluctuations is described by the equation

$$\sigma^2 = \langle (U - \langle U \rangle)^2 \rangle / \langle U \rangle^2,$$

where U is the output signal of a photodetector; angular brackets < > denote time averaging.

The experiment was conducted along a path with the length $L = 130$ m. An LGN-215 He–Ne laser ($\lambda = 0.63$ μm) was employed. The measurements were carried out using a wide collimated beam (the visually determined beam diameter $d_0 \approx 8$ cm) and in the divergent beam ($d_0 \approx 4$ mm) with the divergence angle of 10^{-3} rad. A detector of 0.1 mm in diameter was set at the optical axis of the beam. The receiver field of view was changed discretely with the use of diaphragms installed at the protective hood input. To obtain large fields of view, the hood was shortened. The background from foreign sources was compensated for at the main laser source off. The background was much lower than the working signal. According to our estimates, the relative measurement error was within 15%, as the variance ranged from 0.01 to 1.0.

Figure 1 shows measured variance as a function of logarithm of the receiver field of view in a wide collimated beam. The vertical bars indicate the variance ranges. Filled circles and triangles show the average values. The measurements approximated by the straight line *1* were obtained at the optical depth $\tau \approx 0.1$ and the maximum size of snowflakes $D_m \approx 1$ – 3 mm; line *2* approximates the results obtained at $D_m \approx 10$ mm and $\tau \approx 0.2$; and line *3* corresponds to the absence of precipitation. In line *1*, the values of the receiver field of view were shifted to the left with respect to the measurements in the atmosphere without precipitation and in the case of snowflakes. Lines *1*–*3* are calculated by the least-squares method using the average values of variance.

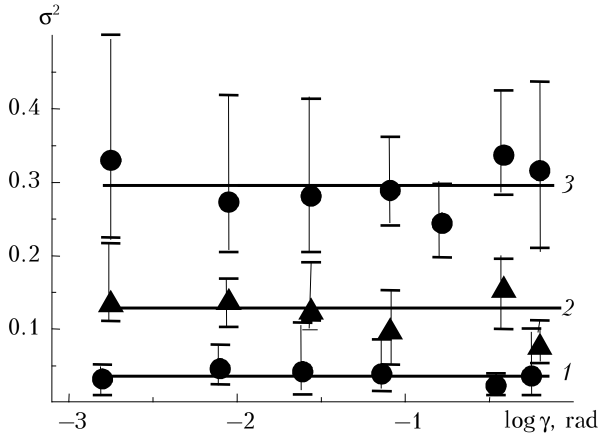

Fig. 1.

Since the receiver field of view in snowfalls is always larger than the diffraction angle, we found no effect of the receiver field of view on the measured variance in both of the beams. This effect is also absent in the case of no precipitation. The contribution of aerosol scattering in this case is low.

Thus, as the receiver field of view varies from $0.9 \cdot 10^{-3}$ to 0.6 rad ($\tau \leq 0.2$), the variance of radiation fluctuations for wide collimated and divergent beams is independent of the receiver field of view in snowfalls and in the turbulent atmosphere (without precipitation).

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References

1. J.R. Clark, J.R. Baird, and R.S. Reardeh, Appl. Opt. **15**, No. 2, 314–315 (1976).

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