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Scattering in Random Propagation Media Using Parabolic Equation

Lal Prasad
Research Scholar, L.N.M.U Darbhanga

Abstract

On this paper, the evaluation of electromagnetic wave propagation thru random media, along with atmospheric turbulence, has been aided by way of the parabolic equation method. The resulting idea has been applied to everything from laser beam propagation to picture propagation within the earth's ecosystem and ocean as well as in other planetary atmospheres. Here, the general stochastic scalar helmholtz wave equation is decreased to a corresponding stochastic parabolic differential equation for the random electric powered area. From this equation, numerous statistical moments of the propagating wave discipline can be derived.

Introduction

This approximate treatment is applicable so long as the wavelength λ of the electromagnetic wave is small in comparison to the characteristic size I_0 of the random inhomogeneity of the permittivity field of the medium. In this case, the scattered radiation from the inhomogeneities is concentrated in a narrow cone with a vertex angle $\theta \sim \lambda / I_0 << 1$. Hence, the scattered waves propagate in essentially the same direction as the primary wave..

Results & Discussion

The figures show the behavior of the on-axis longitudinal MCF, $\Gamma_{11}(x_c, x_d, 0)$, as a function of longitudinal separation, x_d, for a typical Earth atmosphere propagation scenario for a wave source of wavelength $\lambda = 0.63$ μm (red light from, e.g., a helium-neon laser), placed $x_c = 5$ km from the measurement point, for two values of inner scale size (i.e., the smallest inhomogeneity of the turbulent fluctuations): $I_0 = 1.0$ mm and $I_0 = 1.0$ cm, respectively. In both figures, the structure constant of refractive index fluctuations is $C_n^2 = 1\times10^{-12}$ $m^{-2/3}$. Both the real and imaginary values of the MCF are displayed. The oscillatory behavior of the longitudinal MCF is due simply to the movement of the difference coordinate through the Fresnel zones intersecting the longitudinal axis. The oscillations decay because of the loss of longitudinal coherence as the difference coordinate becomes larger.

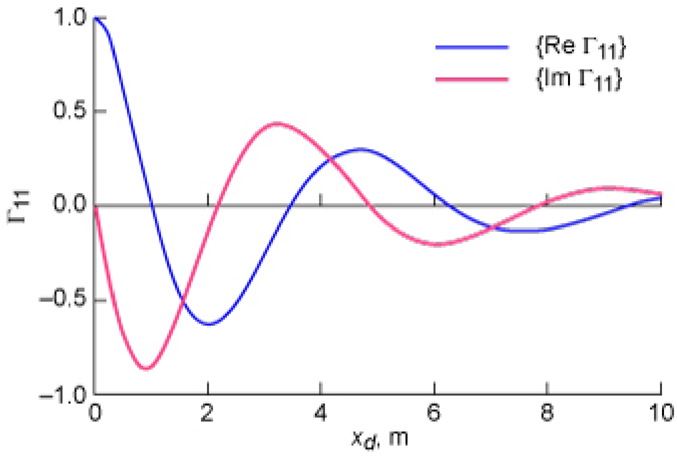

Fig.1

$\Gamma_{11} = (x_c, x_d, 0)$ versus x_d (in meters) for $l = 0.63$ μm, $I_0 = 1.0$ mm, $x_c = 5$ km, and $C_n^2 = 10^{-12}$ $m^{-2/3}$.

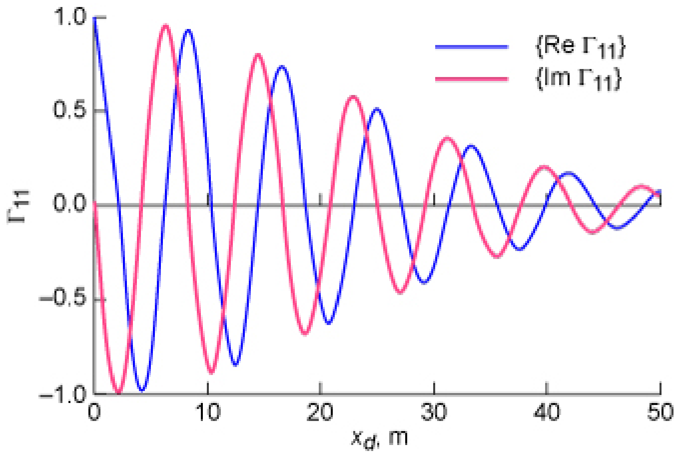

Fig.2

Γ_{11} = (x_c , x_d , 0) versus x_d (in meters) for l = 0.63 μm, I_0 = 1.0 cm, x_c = 5 km, and $C_n2 = 10^{-12}\ m^{-2/3}$.

The characteristic behavior of the longitudinal MCF suggests a potential remote-sensing technique for atmospheric turbulence whereby the inner scales of turbulence can be ascertained on the basis of the spatial frequency of the longitudinal variations. Other results from this study are (1) a complete expression for the transverse and longitudinal MCF for any random medium for which the condition $\lambda \leq I_0$ prevails and (2) a verification of the fact that the classical parabolic equation is applicable for use in a medium characterized by the Kolmogorov spectrum of fluctuations even though $\lambda \sim I_0$. This latter fact is due to the Kolmogorov spectral density level near the inner scale of turbulence being much smaller than it is at the larger scale sizes at which most of the narrow-angle scattering occurs.

References

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