Propagation of Light in Random Waveguide Systems with Slightly Random Imperfections

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From the interest in the crosstalk [1] in an image fiber which is used to transmit directly an optical image, the propagation properties of light in one-dimensional waveguide systems with random geometrical imperfections have been discussed based on the couple mode theory [2, 3]. In the numerical discussion [2] the propagation constants of the modes are generated by using a series of random normal numbers and the coupled mode equation is numerically solved. Although there is no essential difficulty, the numerical calculations for a large system with a very long correlation length are a time consuming task. Besides from the numerical results it is difficult to understand the whole of the dependence of the propagation properties on the structure parameters of the system. In the theoretical discussion [3] the perturbation solution of the couple mode equation is used. Consequently the results obtained are applicable only to the case of a short correlation length.

In this paper a propagation problem of light in a one-dimensional waveguide system composed of an infinite number of cores is treated based on the coupled mode theory. In the system sizes of the cores change slightly along the fiber axis and the propagation constant of the mode is a random function of propagation distance. A solution of the coupled mode equation is derived in a series form with the solution of the coupled mode equation for an ordered system as an initial term. The solution is applicable to the whole range of the correlation length. Using the solution the equations describing the average amplitude and the average power are derived. The equations include two coefficients, the mode coupling coefficient and the damping factor. Light launched into a core spreads over the system with propagation and the light power is transformed into the incoherent power. The mode coupling coefficient determines how light spreads and the damping factor determines the rate of the transformation of the light power into the incoherent power. The mean free path can be obtained from the distance dependence of the damping factor. When the correlation length tends to infinity the mean free path tends to infinity and light propagates coherently in the system. For short correlation lengths the damping factor is proportional to the correlation length. The result agrees with the result obtained using the perturbation solution [3]. For long correlation lengths the damping factor increases gradually compared with the linear dependence on the correlation length.

REFERENCES

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