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Mathematical analysis of the generalized natural modes of an inhomogeneous optical fiber

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Abstract

The eigenvalue problem for generalized natural modes of an inhomogeneous optical fiber without a sharp boundary is formulated as a problem for the set of time-harmonic Maxwell equations with the Reichardt condition at infinity in the cross-sectional plane. The generalized eigenvalues (including, as subsets, the well-known guided and leaky modes) of this problem are the complex propagation constants on a logarithmic Riemann surface. A theorem on spectrum localization is proved, and then the original problem is reduced to a nonlinear spectral problem with a compact integral operator. It is proved that the set of all eigenvalues of the original problem can only be a set of isolated points on the Riemann surface, and it is also proved that each eigenvalue depends continuously on the frequency and refraction index and can appear and disappear only at the boundary of the Riemann surface. © 2005 Society for Industrial and Applied Mathematics.

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Keywords

Eigenvalue problem, Electromagnetic theory, Guided modes, Optical fiber, Waveguides