Recent Progress in the Analysis of Mode Spectrum in Waveguides with Inclusions

Yury Shestopalov(1), Yury Smirnov(2), and Anatolij Il'inski(3)

(1) Faculty of Engineering and Sustainable Development
University of Gävle , SE-801 76 Gävle, Sweden
yuyshv@hig.se

(2) Penza State University, ul. Krasnaya 40, Penza, Russia
smirnovyug@mail.ru
(3) Moscow State University, Moscow, Russia
celd@cs.msu.su

The problems concerning existence, properties, and distribution of the spectrum of normal waves in a broader class of waveguides with inclusions constitute an important issue of theoretical electromagnetics. The fundamental results available for empty waveguides since the late 1940s have been obtained [1, 2] for shielded waveguides with arbitrary metal–dielectric inclusions only recently. It was shown that the spectrum of normal waves is nonempty, forms a countable set of isolated points on the complex plane without finite accumulation points, is localized in a strip symmetrically with respect to the axes on the complex plane, contains not more than a finite number of real points, and the spectral points enter the spectrum in 'fours'. Among many significant conclusions that follow from these results are that the continuous spectrum is absent for a broad family of waveguides including planar slot and strip lines and that complex waves exist, which implies that some properties of planar guiding structures must be reconsidered. The mathematical theory based on the use polynomial operator pencils [1, 2] which was the main tool backing these results can be also applied, in combination with the Galerkin method, for calculation of normal waves as an efficient numerical approach complementing the known FEM, FDTD and other numerical techniques employing discretization. An advantage of the developed operator approach can be clearly seen for waveguides of rectangular cross section with inclusions having the interface boundaries parallel to the waveguide walls when the recently improved parallelized routines [3] for solving very large linear equation systems are applied on supercomputers.

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3. A. Samokhin, Y. Shestopalov, and K. Kobayashi, Stationary iteration methods for solving 3D electromagnetic scattering problems, *Applied Mathematics and Computation,* Vol. 222, pp. 107–122, 2013.