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ABSTRACTS

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It is supposed that everywhere $\mu = \mu_0$, where μ_0 is the permeability of free space. For $R_1 \leqslant \rho \leqslant R_2$ (inside the waveguide Σ) the permittivity ε is described by the formula

$$\varepsilon = \varepsilon_2(\rho) + \alpha\bigl(1 - e^{-\beta|\mathbf{E}|^2}\bigr),$$

where $\min\{\varepsilon_2(\rho) : \rho \in [R_1, R_2]\} > \max(\varepsilon_1, \varepsilon_3)$, $\varepsilon_2(\rho) \in C[R_1, R_2]$, and $\alpha, \beta \geqslant 0$ are real constants.

Complex amplitudes (1) of the TE wave must satisfy Maxwell's equations

$$\begin{cases} \operatorname{rot}\mathbf{H} = -i\omega\varepsilon\mathbf{E}, \\ \operatorname{rot}\mathbf{E} = i\omega\mu\mathbf{H}; \end{cases} \tag{2}$$

the continuity condition for the tangential components of the field on the boundaries $\rho = R_1$ and $\rho = R_2$; and the radiation condition at infinity: the electromagnetic field decays as $O(\rho^{-1})$ when $\rho \to \infty$. The solution is sought for in the entire space.

The continuity conditions for the tangential components are

$$[\mathrm{E}_\varphi]\big|_{\rho=R_1} = 0, \quad [\mathrm{E}_\varphi]\big|_{\rho=R_2} = 0, \quad [\mathrm{H}_z]\big|_{\rho=R_1} = 0, \quad [\mathrm{H}_z]\big|_{\rho=R_2} = 0. \tag{3}$$

Problem P_E: *it is necessary to determine eigenvalues* $\hat{\gamma}$ *for which there exist nontrivial functions* $\mathrm{E}_\varphi(\rho;\hat{\gamma}), \mathrm{H}_\rho(\rho;\hat{\gamma}), \mathrm{H}_z(\rho;\hat{\gamma})$ *that are defined for* $\rho \in (0, +\infty)$*, satisfies equation* (2) *and transmission conditions* (3) (further details and similar problems see in [1–4]).

Numerical results are presented, comparison with linear in- and homogeneous cases is given.

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Parallel computing for numerical calculations of step-index optical fibers eigenmodes by collocation method

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We study the natural modes of a weakly guiding optical fiber, which is a representative of typical optical circuits. In recent years, research on the natural modes of arbitrarily shaped optical fibers has been focused on the development of efficient and reliable computational methods. Many different numerical techniques are applied for computing eigenmodes of optical fibers, namely, Finite-element, Finite-difference, beam propagation, and spline collocation methods, as well as multidomain spectral approach.

The most rigorous efforts were connected with integral equation formulations. Particularly, the problem on surface and leaky eigenmodes of a weakly guiding step-index optical waveguide was considered in our previous works. The original problem was reduced to a nonlinear nonselfadjoint spectral problem for the set of weakly singular boundary integral equations. The integral operator was approximated by collocation method and by Galerkin method. The convergence and quality of these numerical methods was proved by numerical experiments. The collocation method demonstrated better speed of convergence.

In this work we develop the collocation method for numerical calculations of step-index optical fibers eigenmodes. The main difficulty with practical solution of nonlinear nonselfadjoint spectral problems is a calculation of good initial approximations for eigenvalues. We propose to use the singular value decomposition of the collocation method matrix for the initial approximation of eigenvalues. Our numerical experiments showed practical effectiveness of such approach, but singular value decomposition needs in high performance computations. Therefore, we have used the parallel computing technologies (OpenMP and MPI) and have calculated on APK-1 supercomputer. Our software package can be used for numerical simulations of new type's optical fibers.

Diffraction of electromagnetic wave on skin capillary

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Human skin is a very intricate tissue that exhibits complex material behaviour [1]. Due to potential applications in medical diagnostic, therapeutic and surgical procedures, the understanding of optical/electromagnetic properties of biological tissues is an active and important research topic. In this work, we have proposed a theoretical model for the diffraction of electromagnetic wave on the skin blood vessel. For this purpose, the Green's function formalism is used [2]. The wavelength of the incident electromagnetic field for medical purposes is around 1 mm [3], while the standard diameter of the blood vessel is between 0.01–0.2 mm. Therefore, in this paper the problem of diffraction on the capillary located in the layered media is investigated in the long-wave approximation. The basic concept of the model under consideration is shown in Fig. 1, which includes three layers and the blood vessel represented by the cylinder with a wall of uniform thickness.

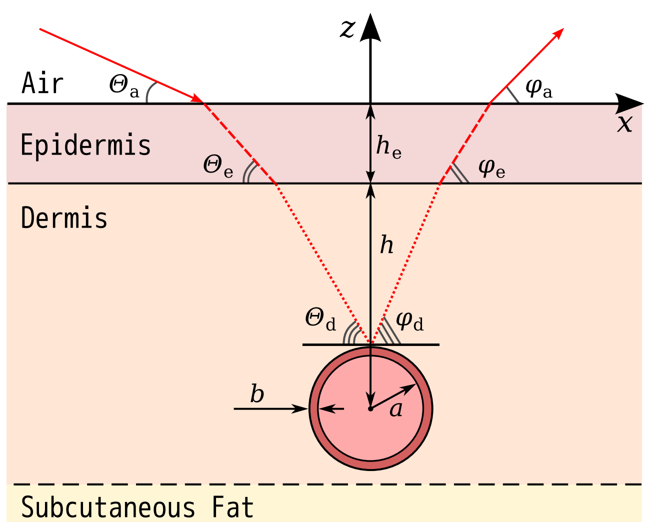

Fig. 1: The simplified three-layer skin structure.

The calculations performed in the paper are based on real experimental data, which makes it more compelling. As an important result of the study, it is established that the amplitude of the scattered field is proportional to the square of the capillary area. Besides, the comparison of simulation results for TE and TM waves allows to determine the dielectric constant of the vessel. For the case of long waves, the reflected field is linearly dependent on the depth position of the capillary. These findings