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Nonlinear Eigenvalues Calculation for Optimal Resonances in One-dimensional Optical Cavities

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Optical cavity is device where the electromagnetic field is well confined. Volume of cavity is a critical parameter than the cavity structure optimization is urgent task [1].

Fundamentals of one-dimensional resonator optimization are described in [2]. The optimization procedure is calculation of cavity structure, when decay of electromagnetic field is minimal. In this case it is considered that cavity consist of layers with piecewise continuous dielectric permittivity in range $\varepsilon_{min}\ldots\varepsilon_{max}$. For derive the optimal structure of cavity are necessary calculate quasi-normal (QN) eigenvalues of nonlinear complex function $W(l,\omega,\theta)$, where l is cavity length, $\omega = \alpha - i\beta$ is complex QN eigenvalue, θ is initial phase of electromagnetic field. Width of layers are defined by solving equations $Re(E(x_k,\omega,\theta)) = 0$, $Im(E(x_k,\omega,\theta)) = 0$, where E is electric field intensity, x_k is width of layer number k.

Functions W, E are transcendental, so calculation of QN eigenvalues is very time consumption problem. For eliminating of calculations procedure of roots localization are developed. Also effective numerical methods of roots calculation are proposed.

[1] Bjorn Maes, Jiří Petráček, Sven Burger, Pavel Kwiecien, Jaroslav Luksch, and Ivan Richter. Simulations of high-Q optical nanocavities with a gradual 1D bandgap. Optics Express, Vol. 21, Issue 6, pp. 6794-6806, 2013.

[2] I.M. Karabash. Nonlinear Eigenvalue Problem for Optimal Resonances in Optical Cavities. Mathematical Modelling of Natural Phenomena. Vol. 8, No. 1, 2013, pp. 143–155.