Bidirectorial Beam Propagation Method Applied for Lasers with Multilayer Active Medium

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Optical devices that have piecewise continuous gain and index distributions along the main propagation direction are widespread. A typical example of such a device is the vertical cavity surface emitting laser (VCSEL). The steady-state oscillating modes of a laser are described by non-linear partial differential equations containing eigenvalues. The problem to find such modes numerically is very difficult on account of several circumstances. The eigenvalue problem of high dimension has to be solved in order to find the modal wave field and frequency of oscillations. The eigenvalue problem is non-linear in the general case because of light-medium interaction. The multilayer medium in the laser cavity complicates considerably the mathematical modeling because of partial reflections from the layer interfaces.

We present the effective numerical method for lasers with multilayer medium based on the bidirectorial beam propagation method (BiBPM). Previously, this method was developed for case of wave propagation through the multilayer structure. The applications of BiBPM for laser devices were restricted by linear eigenvalue problem neglecting influence of the light beam on gain and index of the active medium. The eigenvalue problems for a non-hermitian matrix of high dimension were solved numerically.

The round-trip operator technique is presented in the given paper based on BiBPM. Similarly to traditional Fox-Li technique our method not requires explicit calculation of matrix of the round-trip operator and suits perfectly to Krylov subspace methods of linear algebra. The presented method is extended in natural way to non-linear case taking into account light-medium interaction. The results of modeling of a VCSEL with a resonant array of quantum wells are presented.