# Field representations for optical defect microcavities in 1D grating structures using quasi-normal modes

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Quasi-Normal Modes are used to characterize transmission resonances in 1D optical defect cavities and the related field approximations. Using a mirror field and the relevant QNM, a variational principle permits to represent the field and the spectral transmission close to resonances.

## Summary

When subjected to external excitation, dielectric optical gratings show a resonant response in the time or frequency domain, which can be tailored by inclusion of defects. One can view the structures as open systems which permit the leakage of energy to the exterior, described by the Helmholtz equation with outgoing wave boundary conditions. This constitutes an eigenvalue problem for complex frequencies and the associated field profiles, or quasi-normal modes (QNMs). A theoretical framework for an overall description of optical 1D systems via QNMS is given in [1] and for periodic structures in [2]. We consider single and multiple defect cavities in finite gratings; the theory of [1, 2] has been adapted and implemented in terms of a standard Transfer-Matrix Method . A time-independent perturbation theory for QNM eigenfrequencies is given.

The complex eigenvalues appear to correspond to the position and quality of resonances in the spectral transmission [3]. Splitting the total field of the transmission problem into incoming and scattered parts, as an alternative to [1, 2] we investigated a QNM expansion of only the scattered field, and the related expressions for the transmission and compared to the exact TMM reference. Adequate approximations require summation over many basis modes, even in a spectral region of isolated defect resonances in the band-gap. It turns out that the variational form of the transmission problem [3, 4] offers a resourceful alternative. Using a combination of the mirror field of the structure (without defect) and only one/few relevant QNM(s) as a template, the restriction of the functional of [3, 4] yields an excellent field representation, together with a reasonable approximation of the spectral transmission.

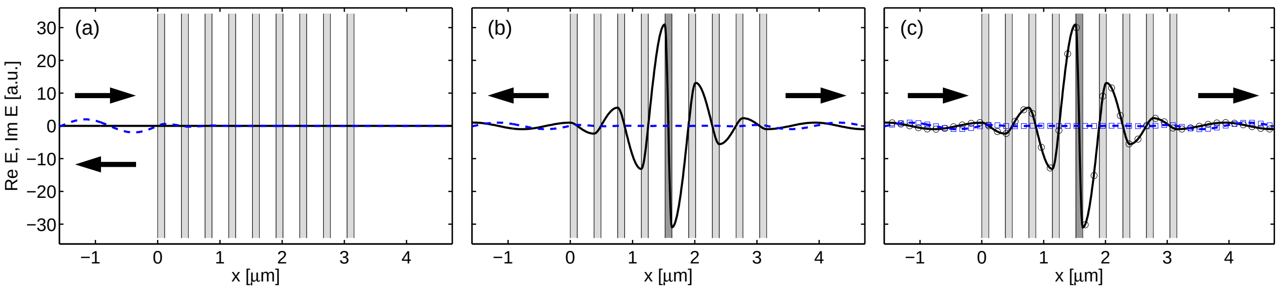


*Figure 1: 1D (defect) grating, field patterns for a (defect) frequency at the center of the bandgap, real (continuous) and imaginary parts (dashed); (a) full reflection for the grating without defect, (b) QNM associated with the defect structure, higher refractive index in the central layer, (c) field associated with the full transmission through the defect grating, variational approximation based on (a, b) (lines) and TMM reference (markers).*

**References**

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