A semi-analytical model for unidirectional guided resonances based on multimodal interference
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1 - Introduction

Recently, optical bound states in the Continuum (BICs) have been produced in photonic crystal slabs. A variation, unidirectional guided resonances (UGRs), has been reported, where the symmetry is broken, leading to leakage in a specific direction [1]. We explore a microscopic semi-analytical model to understand these resonances, by extending a multimodal interference approach of BICs.

The multimodal approach consists of searching for vertically propagating guided modes in a waveguide that has the same dimensions as our geometry. Then by injecting these modes in the upper and lower half of our structure we construct the reflection matrices of two halves of our cell. These matrices gives us information about the way the guided modes interfere in the structure.

2 - Search of guided modes

![Figure 2](image)

**Figure 2** - *Left:* Dispersion curve of a waveguide with same dimensions as our structure. The black line shows the frequency of the UGR. *Right:* Electric field norm of the three guided modes used for interference.

3 - Model

\[ R_d R_u v_u = \lambda v_u \]
\[ R_u R_d v_d = \lambda v_d \]

The eigenvalue \( \lambda \) gives us insight in the resonance:
- If \( \Im(\lambda) \to 0 \) we have a phase resonance.
- If \( \lambda \to 0 \) losses go to zero.

Losses are computed with the eigenvectors and reflection matrices.

\[ T_u = 1 - \frac{\sum |R_u v_u|^2}{\sum |v_u|^2} \]
\[ T_d = 1 - \frac{\sum |R_d R_u v_u|^2}{\sum |R_u v_u|^2} \]

Based on [2] and [3] we constructed the semi-analytical Q factor for the two halves.

4 - Results

![Figure 5](image)

*Figure 5* – Comparison between the Q factor given by our model and an eigenmode solver.

5 - Conclusion and perspectives

As shown on *Figure 5*, our model gives good results in comparison to an eigenmode solver. Meaning that we can describe BICs and UGRs as interferences between fundamental modes. However more investigation are needed to construct a more precise formula for the Q factor.

**Perspectives:**
- Extending the model to more elaborate structures
- Using the multimodal interference to find BICs and UGRs in new geometries
- Connecting our near-field approach with the far-field description of UGRs [1]

**References**


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