Nanophotonic Modeling Lecture 1.17: Targeted Eigensolvers

Prof. Peter Bermel

Targeted Eigensolvers

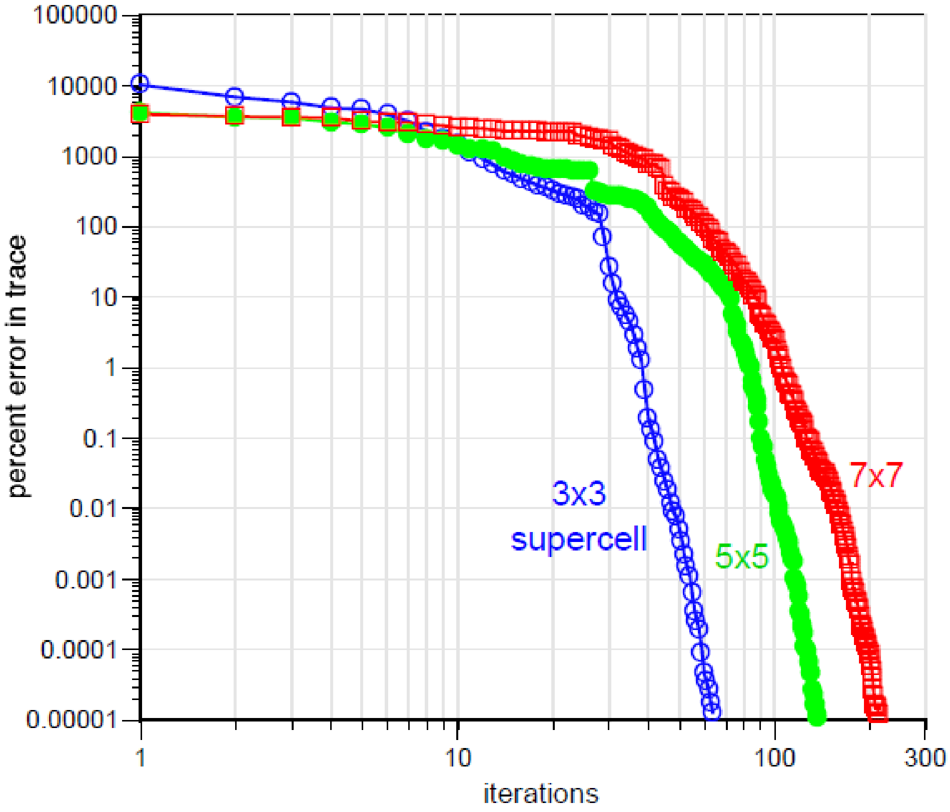
- To find a single defect state in a photonic crystal, use a supercell and shift the target of the eigensolver via:

$$\hat{A}'_{\vec{k}} = \left(\hat{A}_{\vec{k}} - \frac{\omega_m^2}{c^2}\right)^2$$

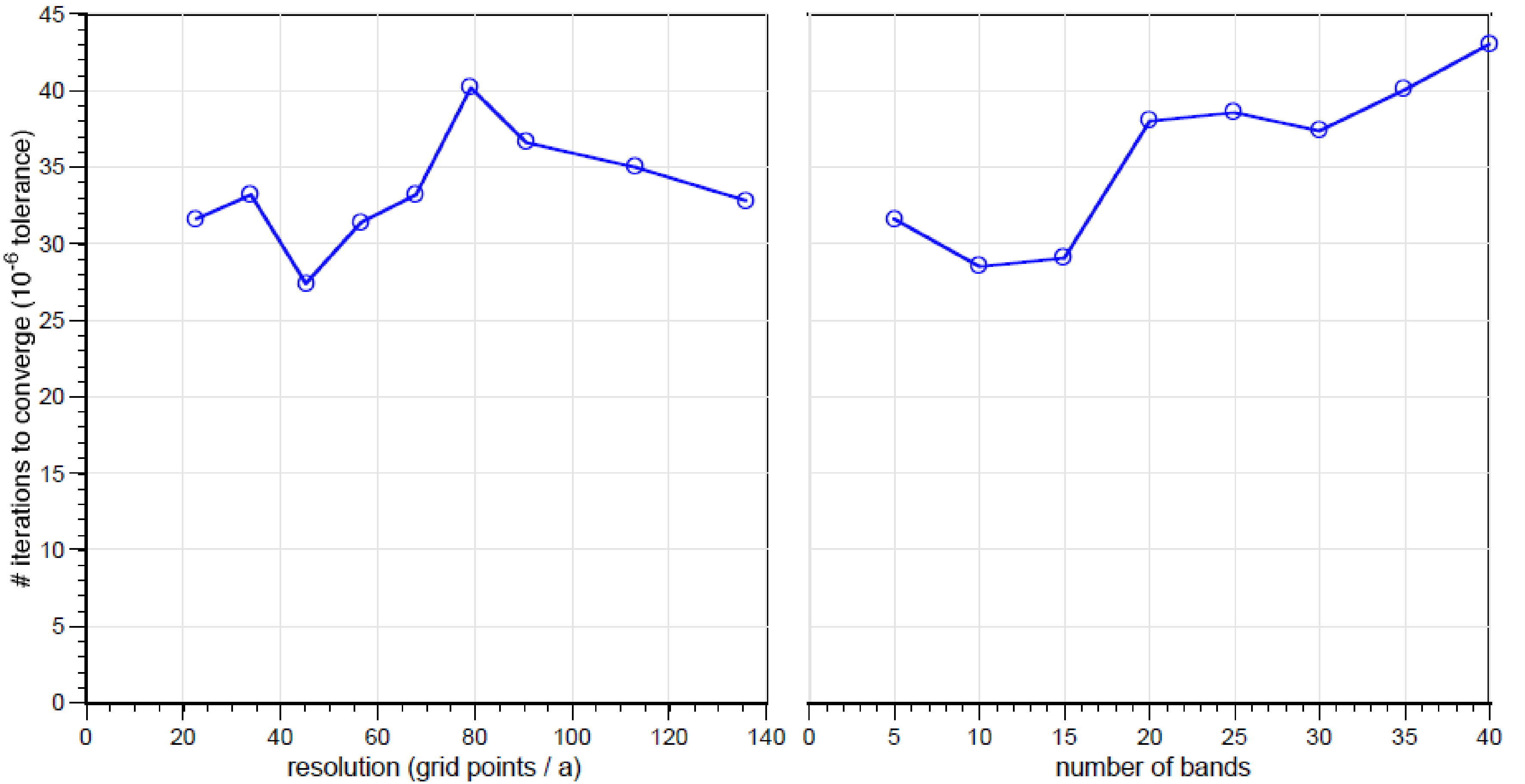
- This yields the same eigenvectors, but shifted eigenvalues-can easily return to original basis

Targeted Eigensolvers

Convergence of targeted eigensolver as the supercell grows still reasonable



Eigensolver Performance



Reformulating the Eigenproblem

- Magnetic field in planewave basis:

$$|H_{\vec{k}}\rangle \cong \sum_{\{m_j\}} \vec{h}_{\{m_j\}} e^{i\sum_{j,k} m_j \vec{G}_j \cdot n_k \vec{R}_k / N_k} = \sum_{\{m_j\}} \vec{h}_{\{m_j\}} e^{2\pi i \sum_j m_j n_j / N_j}$$

- Operator scales like $\mathcal{O}(N \log N)$:

$$A_{\ell m} = -\left(\vec{k} + \vec{G}_\ell\right) \times \cdots \text{IFFT} \cdots \widetilde{\varepsilon^{-1}} \cdots \text{FFT} \cdots \left(\vec{k} + \vec{G}_m\right) \times$$

- Tensor-based averaging aids in convergence:

$$\widetilde{\varepsilon^{-1}} = \overline{\varepsilon^{-1}} P + \overline{\varepsilon}^{-1} (1 - P) \qquad P_{ij} = n_i n_j$$

- MPB performs conjugate-gradient minimization of Block Rayleigh quotient