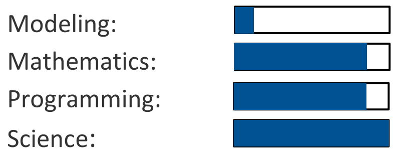
Chair of Computational Modeling and Simulation
TUM School of Engineering and Design
Technical University of Munich



Software Lab:

Projection-based and data-driven parametric model order reduction for the analysis of periodic structures

Description

Wave propagation in periodic structures is typically characterized by the dispersion relation, which maps how eigenfrequencies evolve as a function of the wavenumber (Fig. 1 and 2). Numerically, the Wave Finite Element Method (WFEM) is a versatile but computationally expensive tool to compute this dispersion relation since an eigenvalue problem of a FE model of the unit cell must be solved for many instances of the wavenumber. For multi-query analyses like uncertainty quantification or optimization, the computational complexity increases further as repeated WFEM simulations must be performed for changes in the parameters of the unit cell. Parametric model order reduction (pMOR) methods aim at providing accurate approximations of the solution of the high-fidelity model with significantly less computational effort while also maintaining the parametric dependency of the high-dimensional FE model. In this project, projection-based and data-driven pMOR methods shall be applied to accelerate the computation of dispersion relations of periodic structures.

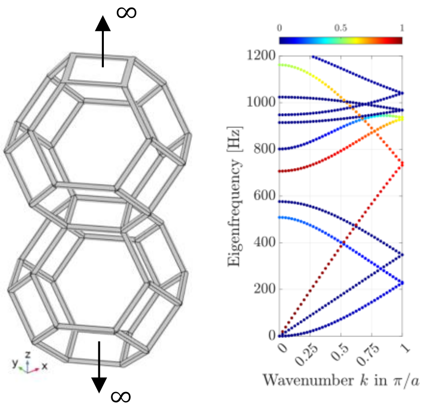


Fig 1: Unit cell with 0° degree twist and corresponding dispersion curve [4]

Tasks

- get familiar with projection-based MOR approaches for the WFEM [1] and implement them in combination with a pMOR method [2]
- get familiar with data-driven pMOR methods for the dispersion relation [3] and implement them
- compare the implemented approaches with respect to their accuracy and their computational effort

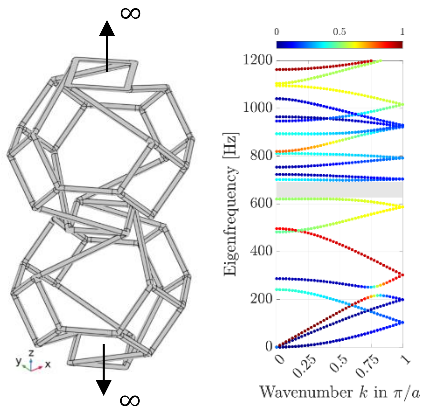


Fig 2: Unit cell with 90° degree twist and corresponding dispersion curve [4]

Supervisor

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References

[1] Krattiger, D., & Hussein, M. I. (2014). Bloch mode synthesis: Ultrafast methodology for elastic band-structure calculations. Physical Review E, 90(6), 063306.

[2] Benner, P., Gugercin, S., & Willcox, K. (2015). A survey of projection-based model reduction methods for parametric dynamical systems. SIAM review, 57(4), 483-531.

[3] Alghamdi, M. M., Bertrand, F., Boffi, D., Bonizzoni, F., Halim, A., & Priyadarshi, G. (2022). On the matching of eigensolutions to parametric partial differential equations. arXiv preprint arXiv:2207.06145.

[4] Kleine-Wächter, L., Rumpler, R., Mao, H., Göransson, P., & Müller, G. (2022). Numerical study of Kelvin cells for the design of periodic lattice metamaterials. In International Conference on Noise and Vibration Engineering (ISMA).