FFT-based homogenisation accelerated by low-rank approximations

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Abstract

Fast Fourier transform (FFT) based methods has turned out to be an effective computational approach for numerical homogenisation. Particularly, Fourier-Galerkin methods are computational methods for partial differential equations that are discretised with trigonometric polynomials. Its computational effectiveness benefits from efficient FFT based algorithms as well as a favourable condition number. Here this kind of methods are accelerated by low-rank tensor approximation techniques for a solution field using canonical, Tucker, and tensor train formats. This reduced order model also allows to efficiently compute suboptimal global basis functions without solving the full problem. It significantly reduces computational and memory requirements for problems with a material coefficient field that admits a moderate rank approximation. The advantages of this approach against those using full material tensors are demonstrated using numerical examples for the model homogenisation problem that consists of a scalar linear elliptic variational problem defined in two and three dimensional setting with continuous and discontinuous heterogeneous material coefficients. This approach opens up the potential of an efficient reduced order modelling of large scale engineering problems with heterogeneous material.