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Sparsifying high-dimensional, multiscale Fourier spectral methods

Fast Fourier transforms (FFT) have made Fourier spectral methods extremely popular for solving partial differential equations (PDE). However, when very fine frequency scales of PDE data and solutions need to be resolved, the superlinear dependence on bandwidth in FFTs' computational complexity makes traditional spectral methods infeasible. The exponential dependence on the spatial dimension of the problem only exacerbates this computational intractability.

Sparse Fourier transforms (SFT) on the other hand have enjoyed great success at computing univariate functions' most significant frequency data while running with computational complexity sublinear in the bandwidth. This talk will discuss the extension of SFTs to high-dimensions, where the emphasis on sparsity both bypasses the currse of dimensionality and superlinear dependence on wide frequency bands. These techniques then allow for the sparsification of a traditional spectral method. We present an adaptive algorithm for quickly solving extremely high-dimensional, multiscale diffusion equations. The algorithm is furnished with error guarantees on the solution in terms of the Fourier-compressibility of the PDE data and the ellipticity of the problem.