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Hierarchical Matrices for Convection-Dominated Problems

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Abstract: Hierarchical matrices ($\mathcal{H}$-matrices) provide a technique for the sparse approximation of large, fully populated matrices. This technique has been shown to be applicable to stiffness matrices arising in boundary element method (BEM) and finite element method (FEM) applications. In the latter case, it is the inverse stiffness matrix that is fully populated and approximated by an $\mathcal{H}$-matrix.
For elliptic operators with L^∞-coefficients, it has been shown that the standard partitioning algorithm in connection with the standard admissibility condition lead to hierarchical matrices that approximate the (inverse) of the stiffness matrix with an error of the same order as the discretization order while having nearly optimal storage complexity.
In this talk, we will briefly review the standard construction of $\mathcal{H}$-matrices. We will then demonstrate the shortcomings of applying the standard partitioning and admissibility condition to the singularly perturbed convection-diffusion equation. We will construct a modified (hierarchical) partitioning of the index and block index sets together with a modified admissibility condition, both depending on the (constant) convection direction and the grid parameter h. An important observation is that the $\mathcal{H}$-matrix approximant benefits from the convection direction aligning with the underlying grid. Numerical results will illustrate the effect of the proposed changes.

[1] S. Le Borne, *$\mathcal{H}$-matrices for convection-diffusion problems with constant convection*, to appear in Computing (2003)

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