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A Fast Iterative Solver for Acoustic Scattering by Objects in Layered Media

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We consider the computation of time-harmonic acoustic scattering by objects in layered media. An example of such problem is the scattering by a mine buried in sediment. The computational domain can be tens or hundreds of meters long while the target requires modeling of details smaller than one centimeter. A discretized problem can have several billion degrees of freedom.

We decompose the computational domain into far-field and near-field domains and then we perform a finite element discretization. For the vastly larger far-field domain we use an orthogonal mesh and a preconditioner based on a fast direct solver. For the near-field domain a more standard preconditioner can be used. The combination of these two defines a preconditioner for the GMRES method. An essential implementation detail is the reduction of iterations into a small sparse subspace. Due to this the memory usage is essentially reduced and the GMRES method can be used without restarts.

We present numerical results with two-dimensional and three-dimensional problems demonstrating the efficiency of the proposed approach. For example, we show that it is possible to solve problems with more than a billion degrees of freedom on a modern PC.