"Sweeping preconditioner for optimized Schwarz domain decomposition methods applied to the Helmholtz equation"

In terms of computational methods, solving three-dimensional time-harmonic wave problems is known to be challenging, especially in the high frequency regime. The brute-force application of the finite element method to the Helmholtz equation leads to the solution of very large, complex and possibly indefinite linear systems. Direct sparse solvers do not scale well for such problems, and Krylov subspace iterative solvers can exhibit slow convergence, or even diverge. Domain decomposition methods provide an alternative, iterating between subproblems of smaller sizes, amenable to sparse direct solvers. In this talk I will present a non-overlapping Schwarz domain decomposition method that exhibits quasi-optimal convergence properties, i.e., with a convergence that is optimal for the evanescent modes and significantly improved compared to competing approaches for the remaining modes. These improved properties result from a combination of an appropriate choice of transmission conditions and a suitable approximation of the Dirichlet-to-Neumann boundary operators. I will then introduce a sweeping preconditionner that approximates the inverse of the iteration operator for a layered partitioning of the domain, which dramatically increases the computational throughput on massively parallel computers when combined with the pipe-lining of multiple right-hand sides.