Reduced order models, networks and applications to modeling and imaging with waves.

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Geophysical electromagnetic and seismic exploration, as well as radar and sonar imaging require the solution of large scale forward and inverse problems for hyperbolic systems of equations. In this talk I will show how model order reduction can be used to address some intrinsic difficulties of these problems. In model order reduction, one approximates the response (transfer function) of a large scale dynamical system using a smaller system, called the reduced order model (ROM). We consider ROMs that capture properties of the large problem that are essential for imaging and that can be realized via sparse graph-Laplacian networks. The ROMs are data-driven, i.e., they learn the underlying PDE problem from the transfer function. One of the better known applications of our ROMs is the spectral Lanczos decomposition for the solution of the diffusion Maxwell's equation and discretization of the perfectly matched layer (PML). Here I will focus on two recent applications: (i) Multiscale modeling of wave propagation via network approximations, with low communication and computational cost; (ii) A direct, nonlinear imaging algorithm in strongly heterogeneous media, where the ROM is used to manipulate the data in such a way that multiply scattered waves are separated from the single scattered ones.