Improving numerical efficiency: model reduction, high-order vs. low-order & continuous vs. discontinuous Galerkin

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First, a reduced order model is presented in the context of a Helmholtz equation with non-constant coefficients in an unbounded domain. This problem requires large numbers of degrees of freedom because relatively high frequencies with small (compared with the domain size) geometric features must be considered. The incoming dimensionless wave length and its direction are the two parameters introduced in the reduced order model: the Proper Generalized Decomposition (PGD). This method imposes a separated representation of the approximation and uses operators associated to the weak form of the problem but not the solution itself as Proper Orthogonal Decomposition techniques. Consequently, the PGD determines the separated representation without the a priori knowledge of any solution. This technique is successful in elliptic and parabolic problems and with the proper error estimates based on quantities of interest the number of terms can be satisfactorily estimated. But its application to a wave-propagation problem is not trivial.

The second part of the talk addresses two questions which continuously emanate in advanced computational engineering: are high-order approximations better/worse than low-order ones? and can Discontinuous Galerkin (DG) be more efficient than Continuous Galerkin (CG)? Obviously, these two questions are confronted in the context of the problem at hand. To compare high versus low order approximations apart from run-time comparisons, which are clearly dependent on implementation and hardware, operation count is proposed. Then, the issue of DG vs. CG is addressed. This is analyzed again with a simple operation count. In particular, the number of non-zero terms in the matrix is computed. Results are clear for uniform order meshes when CG is compared with Compact DG (CDG) and Hybridizable DG. But p-adaptive DG is also compared.