Towards scalable and efficient implicit finite element simulations for plasma physics applications on HPC platforms

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ABSTRACT

Plasma physics models describe important natural phenomena and technological applications such as magnetically confined fusion energy and pulsed fusion reactors. Accurate numerical simulations require high fidelity solutions. Fully-coupled implicit Newton-Krylov finite element method approaches can be advantageous because of their robustness for complex multiphysics problems. However, they require the scalable solution of very large sparse linear systems. Multilevel/multigrid-based methods offer one potential approach for obtaining scalable solutions. We examine the performance of a fully-coupled algebraic multigrid (AMG) [1-4] preconditioned Newton-Krylov solution approach for a finite element variational multiscale (VMS) model on unstructured meshes for a few continuum plasma physics models. Many of the current and future large DOE platforms include many-core processors and GPUs. Achieving scalable and efficient solutions on these platforms is extremely challenging. The Trilinos [5] finite element assembly and solver libraries are in the process of being rewritten to employ Kokkos [6] to handle future architectures. Our application employs Trilinos finite assembly libraries for matrix assembly. We will present results for threaded matrix assembly on many-core processors and GPUs.

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