Towards the next-generation computational multiscale multiphysics algorithm

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Abstract:

A predictive capability is an important and desirable feature for development of next generation Multiphysics simulation tools. Due to recent paradigm shift in high performance computing, achievement of next level computer performance (i.e., exascale) has led to disruptive architectural changes. Efficient use of the highly heterogeneous HPC platforms requires new physics algorithms and computational designs development. ASC ATDM project is focusing on developing new simulation tools that address emerging HPC challenges of massive heterogeneous parallelism using novel programing model and data management.

Many physical systems are inherently multiscale. For example, aparticle behavior may be modelled by the Liouville-Boltzmann, and/or continuum equations, depending on the required physical fidelity. Although the low-fidelity models may become equivalent in an asymptotic regime, it generally requires appropriate high-fidelity closure models (e.g., pressure tensor via EOS, Eddington Tensor for Quasi-Diffusion) in order to achieve an acceptable accuracy. On the other hand, the high-fidelity models soon become computationally intractable due to their large dimensionality. Efficiency and accuracy of a predictive tool can be attained only via a novel, scale-bridging algorithm.

In this presentation, we first discuss some of main thrust areas at the fluid dynamics and solid mechanics group (T-3) at Los Alamos National Laboratory so as o provide examples of multiscale, multiphysics systems. Then, we introduce the “nonlinear multigrid” idea, and demonstrate the applicability of the concept to multiscale systems. The mathematical framework of nonlinear multigrid enables systematic derivation of multiscale algorithms. We use radiation transport as an example application. Finally, we will discuss next-generation multiphysics code development effort within the ASC ATDM projects. Here, we will focus on how to extend the scale-bridging algorithm framework into multiphysics simulation tools, including the co-design process.

Bio:

Ryosuke (HyeongKae) Park joined LANL in 2011 as a staff member in Fluid Dynamics and Solid Mechanics group (T-3) in the Theoretical Division. Before joined LANL, he was a staff member at Idaho National Laboratory. His general research interests are the development of multiphysics numerical algorithm for radiation (photons, neutrons) transport. He has extensive knowledge and background in nonlinear acceleration, scale-bridging, physics-based preconditioning and high-order discretization including adaptivity. Applications includes astrophysics, inertial confinement fusion and other high-energy-density physics as well as nuclear energy systems. He has over 50 peer-reviewed journal publications and conference proceedings.