Missing Mathematics for Extreme-scale Simulation

SciDAC-2: Towards Optimal Petascale Simulations
FSP: Center for Plasma Edge Simulation
FSP: Center for Simulation of Wave Interactions with MHD
ISICLES: Modeling the Fracture of Ice Sheets

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Abstract

An oft-quoted motivation for extreme computing is to "take the gloves off" with critical energy and environmental simulations: improve prediction by relaxing the decoupling, rolling out the full physics, cranking up the resolution, and quantifying the uncertainty. Meeting these objectives will indeed justify the daunting development, acquisition, and operation costs of the hardware. New hardware is, however, only one challenge and perhaps neither the highest risk nor the highest payoff. Much mathematics (and software) appears to be missing if the hardware is to be used at its potential. For instance, the promises of multiphysics simulation will not be realized in extreme-scale computational environments in the primary manner through which codes are coupled today, through divide-and-conquer operator splitting. Furthermore, today's successful, decoupled applications will need to be substantially rewritten after two decades of algorithm refinement in a period of programming model stability. While undertaking the latter, it may be natural to rethink the former.