

Computing at the Extreme Scale:

Scientific and Computational Challenges in Fusion Energy Sciences

William TANG

Princeton University, Plasma Physics Laboratory

Advanced computing is generally recognized to be an increasingly vital tool for accelerating progress in scientific research in the 21st Century. The imperative is to translate the combination of the rapid advances in super-computing power together with the emergence of effective new algorithms and computational methodologies to help enable corresponding increases in the physics fidelity and the performance of the scientific codes used to model complex physical systems. If properly validated against experimental measurements and verified with mathematical tests and computational benchmarks, these codes can provide reliable predictive capability for the behavior of fusion energy relevant high temperature plasmas. The fusion energy sciences community has made excellent progress in developing advanced codes for which computer run-time and problem size scale well with the number of processors on massively parallel supercomputers. A good example is the effective usage of the full power of modern leadership class computational platforms from the terascale to the petascale and beyond to produce nonlinear particle-in-cell simulations which have accelerated progress in understanding the nature of plasma turbulence in magnetically-confined high temperature plasmas. Illustrative results from provide great encouragement for being able to include increasingly realistic dynamics in extreme-scale computing campaigns to enable predictive simulations with unprecedented physics fidelity.

KEYWORDS: Exascale, extreme computing, particle-in-cell, fusion energy sciences