Special

APPLIED MATH COLLOQUIUM

Sparse and multi-scale numerical methods for the kinetic equations of plasma dynamics

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ABSTRACT:

Kinetic partial differential equations are a fundamental and crucial tool for understanding the dynamics of plasmas far from local thermodynamic equilibrium. Their accurate and efficient numerical solution presents a host of challenges - in this talk we will focus on two in particular: their high-dimensionality (6-D plus time in the most general case) and the presence of multiple disparate time-scales. The high-dimensionality in particular has motivated a hybrid grid/particle algorithm called particle-in-cell (PIC). Though tremendously successful, we show that PIC features the slow convergence of a particle method without fully eliminating the curse of dimensionality. We present a modification of PIC using so-called sparse grids that results in an algorithm whose complexity depends only logarithmically on the dimensionality of the problem. Turning to the multiple time-scale challenge, we discuss recent work on anasymptotic preserving time-integrator for PIC that allows us to step over the short gyration time-scale present in the strongly magnetized plasmas appearing in nuclear fusion. In each case, numerical results will be presented and avenues for future work discussed.

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