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Discrete Velocity Methods and Adaptive Kinetic-Fluid Models[1]
VLADIMIR KOLOBOV, CFD Research Corporation — The particle transport in plasma can be described by either kinetic or hydrodynamic (fluid) models. Kinetic models provide detailed description in terms of particle velocity distributions, which obey the Boltzmann, Vlasov, and Fokker-Planck kinetic equations. Direct numerical solution of the kinetic equations can be obtained using discrete velocity methods. The fluid models describe plasma on a macroscopic level and provide coupling between the particle transport and electromagnetics. In this tutorial, we will describe the kinetic solvers based on discrete velocity methods and hybrid kinetic-fluid models combining the accuracy of kinetic solvers with the efficiency of fluid models. Adaptive kinetic-fluid models are particularly important for plasma, which is characterized by a wide range of temporal and spatial scales due to the disparity of electron mass and the masses of heavy species (ions, atoms). The research challenges in this field are associated with identifying correct criteria for selecting appropriate models (which are different for electrons, ions, atoms, and photons), closure of fluid models for collisional and collisionless plasmas, coupling kinetic and fluid solvers at interfaces (which can dynamically evolve), and implementing these hybrid algorithms into smart software for practical plasma engineering on modern computing systems.

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Vladimir Kolobov
CFD Research Corporation

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