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Towards adaptive kinetic-fluid simulations of low-temperature plasmas[1]

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The emergence of new types of gaseous electronics in multi-phase systems calls for computational tools with adaptive kinetic-fluid simulation capabilities. We will present an Adaptive Mesh and Algorithm Refinement (AMAR) methodology for multi-scale simulations of gas flows and discuss current efforts towards extending this methodology for weakly ionized plasmas. The AMAR method combines Adaptive Mesh Refinement (AMR) with automatic selection of kinetic or fluid solvers in different parts of computational domains. This AMAR methodology was implemented in our Unified Flow Solver (UFS) for mixed rarefied and continuum flows. UFS uses discrete velocity method for solving Boltzmann kinetic equation under rarefied flow conditions coupled to fluid (Navier-Stokes) solvers for continuum flow regimes. The main challenge of extending AMAR to plasmas comes from the distinction of electron and atom mass. We will present multi-fluid, two-temperature plasma models with AMR capabilities for simulations of glow, corona, and streamer discharges. We will briefly discuss specifics of electron kinetics in collisional plasmas, and deterministic methods of solving kinetic equations for different electron groups. Kinetic solvers with Adaptive Mesh in Phase Space (AMPS) will be introduced to solve Boltzmann equation for electrons in the presence of electric fields, elastic and inelastic collisions with atoms. These kinetic and fluid models are currently being incorporated into AMAR methodology for multi-scale simulations of low-temperature plasmas in multi-phase systems.

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