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Recent progress in plasma modeling for streamers and electrical propulsion

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Plasma modeling is crucial for comprehending the behavior of ionized gases in various environments, including fusion reactors, space propulsion systems, and plasma-based materials processing and synthesis. Accurate plasma models can help optimize the design and operation of these systems, leading to more effective and efficient use of plasma-based technologies across multiple industries. In the past fifteen years, our team has conducted extensive modeling and numerical investigations on streamer discharges and plasma thrusters. A 3D particle model was developed for precise simulations of streamer discharge structures[1], and multi-dimensional fluid models were used for discharges in a larger time or spatial scale[2]. A kinetic model with PIC/MCC method for charged particles and direct simulation Monte Carlo method for neutral gas is developed for investigating the plasma process in electric thrusters[3]. A series of acceleration technology techniques are implemented to improve the computational efficiency of our models, such as parallelization, adaptive particle management, adaptive mesh refinement, hybrid method and implicit method. The developed models were used to investigate various types of discharges, including single filament streamers[4], branching streamers[5,6], diffusive ionization waves[7], and dielectric barrier discharges[8], employing both experimental and computational approaches, as shown in figure 1. Good agreements were achieved between experimental and computational results, indicating the accuracy and reliability of our models. The kinetic model for thrusters has been successfully applied in the simulations of the inductively coupled plasma and the beam extraction of ion thrusters.

References

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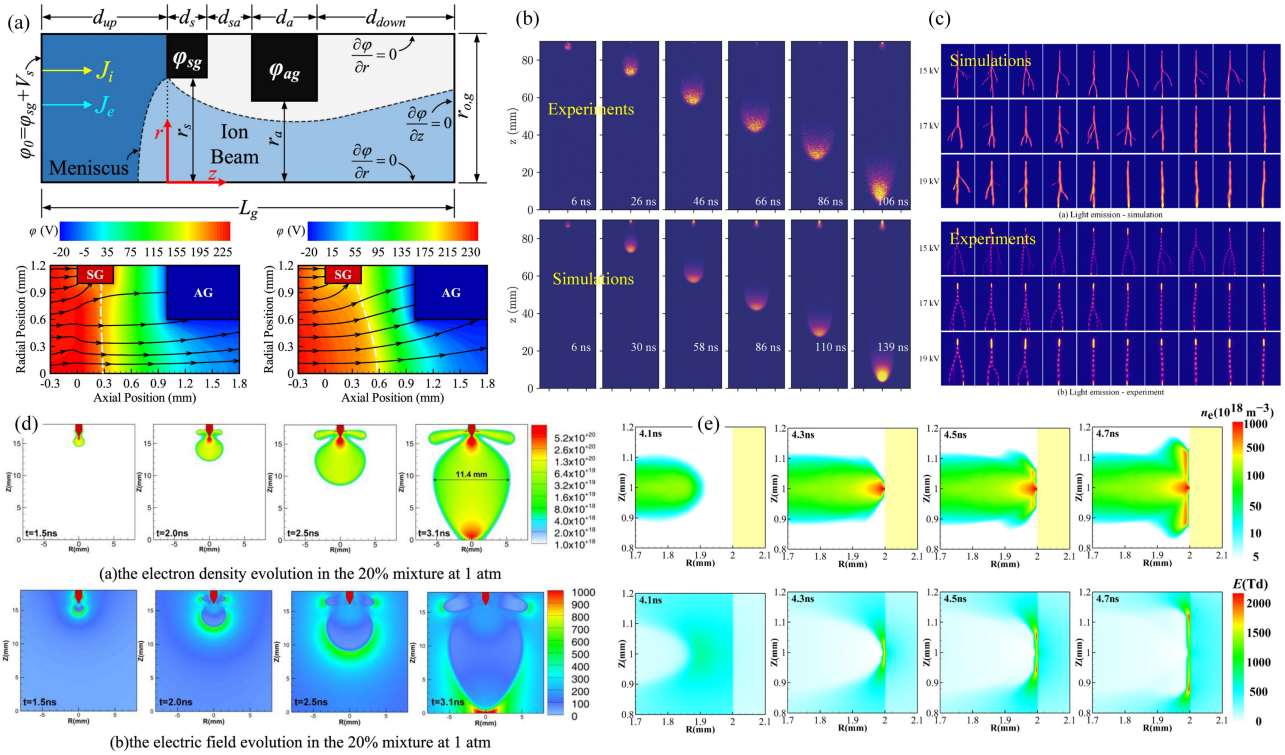

Figure 1. Applications of our plasma models: (a) plasma process in electric thrusters[3], (b) single filament streamers[4], (c) branching streamers[5], (d) diffusive ionization waves[6], and (e) dielectric barrier discharges[7].