Abstract for an Invited Paper
for the DPP09 Meeting of
The American Physical Society

Kinetic simulations of plasma sheath with parallel to the wall magnetic field[1]

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Plasma-wall interactions can play an important role in plasma transport and confinement. The sheath serves as a boundary between the interior quasi-neutral plasma and the wall's surface and can impact the energy and particles fluxes striking the vessel, and consequently can influence the choice for the wall material. As hotter and denser plasmas are confined by almost parallel to the wall magnetic field in current fusion experiments, the need to understand this particular type of plasma sheath is apparent. For example, in magnetized target fusion the confining B field remains mostly parallel to the converging liner surface, while on ITER, the magnetic field intercepts the main chamber and the divertor plates at no more than a couple degrees. The physics of such plasma sheath is fundamentally different from the conventional one, as it is the ions that are positively charging the wall due to their large Larmor radii. Detailed 1D and 2D kinetic simulations using VPIC[1] suggest that the particles' distribution functions in the sheath significantly deviate from a local Maxwellian (contrary to common assumption in analytical theory[2]). The anomalies in the distribution functions are quantified by analyzing the particles drift velocities and the roles of different parts that make up the sheath force balance, such as electric field, Lorentz force, pressure gradient, and viscosity tensor. Scanning of plasma parameters yields a scaling of the sheath width with magnetic field and electron and ion temperatures that differs from conventional Debye-length scaling. The instabilities due to non-Maxwellian particles distribution functions, pressure gradient, and sheared ExB flow are also considered and compared with the observed dynamical fluctuations in both 1D and higher dimensional simulations.

[1] K. J. Bowers, et al. Phys. Plasmas 15, 055703 (2008).
[2] U. Daybelge, et al. Phys. Fluids 24 (6) (1981).

[1]Work supported by OFES and LANL LDRD.