DPP19-2019-001615

Abstract for an Invited Paper
for the DPP19 Meeting of
the American Physical Society

Reduction of the Plasma Electron Temperature to the Emitted Electron Temperature Near Thermionic Surfaces with Inverse Sheaths[1]

MICHAEL CAMPANELL, Lawrence Livermore Natl Lab

Understanding the effects of thermionic surfaces on plasmas is important in many research areas. Examples include tokamak divertors, emissive probes, Hall thrusters, hypersonic vehicles, the Large Plasma Device, and arcs. The conventional view from Langmuir's era through modern times was that emitting sheaths are classical or space-charge limited (SCL). Classical and SCL sheath models [1,2] assume that plasma electrons near the surface are confined and can have any temperature, independent of the thermionic temperature. However in recent works we showed that under strong enough emission, conventional theory breaks down and the sheath inverts. The inverse regime is unique because no plasma electrons are confined. Also, because thermoelectrons are not accelerated by an inverse sheath, they flood the quasineutral region with electrons at the thermionic temperature Temit. This forces Te near the surface to equal Temit (generally below 0.3eV) regardless of how hot the upstream plasma is [3]. We confirm the extreme cooling effect of inverse sheaths in continuum kinetic simulations by comparing classical, SCL and inverse sheath regimes in plasmas with equivalent hot upstream temperatures. One potential application is that thermionic divertor plates with inverse sheaths could constrain the target plasma to a sub-eV temperature sufficient for detachment and thereby mitigate the plasma-wall interaction [3]. Inverse sheath detachment may have advantages over conventional detachment scenarios that rely on injecting neutrals, which are liable to compromise the core plasma. Other recent advances, experiments, and open questions regarding inverse sheath effects in plasma physics will be reviewed with applications to hot cathode devices, emissive probe measurements, and negative ion sources. [1] S. Takamura et al., Contrib. Plasma Phys. 44, 126 (2004). [2] J.P. Sheehan et al., PRL 111, 075002 (2013). [3] M.D. Campanell and G.R. Johnson, PRL 122, 015003 (2019).

[1]This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract no. DE-AC52-07NA27344 and supported by the DOE Office of Science, Fusion Energy Sciences.