DAMOP14-2014-000776

Abstract for an Invited Paper
for the DAMOP14 Meeting of
the American Physical Society

LIF studies of Discharge Plasma Sheaths[1]

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Sheath formation in plasma discharges is a collective effect characteristic of the plasma state of matter, and in single ion species plasmas it is well understood in terms of the Bohm Criterion. However, plasmas often contain several positive ion species. This complicates the physics of sheath formation. Many theoretical studies suggest that each of the ion species reach the sheath edge at their individual Bohm speeds. We carried out the first laser-induced fluorescence (LIF) Ar+ measurements in the presheaths of weakly collisional Ar+He plasmas and showed that this was not generally the case. When the Ar and He species had comparable densities, ions were found reach the sheath edge with nearly the same speed, the ion sound speed of the bulk plasma. We broadened the scope of the measurements to include Ar+Xe, and He+Xe plasmas. Ion velocity distribution functions (IVDFs) in the Ar+Xe case were measured with LIF with separate (tunable diode) lasers. In all cases, each species reached the sheath edge at close to the system sound velocity when the ion densities are comparable, and if the ratio of the ion densities are very large or small compared to one, each ion species reaches the sheath edge at its individual Bohm speed. Our results are in good agreement with the kinetic theory of instability enhanced ion-ion friction of Baalrud et al. We report on this and on the development of the Kr+ ion flow diagnostic using a tunable diode laser undertaken in order to significantly increase the number of two ion plasma mixtures for which both ions may be diagnosed. More recently, our LIF studies have uncovered evidence of anomalous ion-ion collisionality in single ion species plasmas that play a role in single ion species sheath formation. We contributed to the development of LIF schemes suitable for diode lasers for Ar, Xe, and now Kr discharges. Issues related to atomic physics, signal to noise, and deconvolution will be discussed.

[1]Work supported by U.S. Department of Energy Grant Nos. DE-FG02-97ER54437, and DE FG02-03ER54728, National Science Foundation Grants Nos. CBET-0903832, CBET-0903783, and PHYS-1206421.

[2]Collaboration with Dr. Chi-Shung Yip and Dr. Noah Hershkowitz, Dept. of Engineering Physics, University of Wisconsin-Madison, is gratefully acknowledged