Universality of the upstream ion to electron temperature ratio dependence on the normalized collisionality in the scrape-off layer of magnetically confined devices

Y. Li¹,2, J. P. Gunn¹, X. Liu², G. Xu², J. Morales³, C. Gil³, F. Clairet³, D. Vezinet³, N. Yan², S. Liu², A. Nielsen⁴, E. Tsitrone³, S. Brezinsek¹, Y. Liang¹, C. Xiao²,5, J. Geiger⁶, C. Killer⁶, O. Grulke⁶, M. Jakubowski⁶, M. Otte⁶, the EAST team⁹, the WEST team⁷ and the W7-X team⁸

¹Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung – Plasmaphysik, Partner of the Trilateral Euregio Cluster (TEC), 52425 Jülich, Germany
²Institute of Plasma Physics, Chinese Academy of Sciences, Hefei 230031, China
³CEA, IRFM, F-13108 Saint-Paul-lez-Durance, France
⁴Department of Physics, Technical University of Denmark, Kgs. Lyngby, Denmark
⁵Department of Physics and Engineering Physics, University of Saskatchewan, 116 Science Place, Saskatoon, SK S7N 5E2, Canada
⁶Max-Planck-Institut für Plasmaphysik, Greifswald, Germany
Corresponding author: y.li@fz-juelich.de or ylli@ipp.ac.cn

In this paper we analyze the retarding field analyzer and Langmuir probes measurements in the magnetic confinement devices, EAST and WEST and presents the dependence of the upstream plasma parameters, ion and electron temperature and their ratio (Ti/Te), on the plasma control parameters, upstream plasma density, SOL power and magnetic field line connection length. Ion and electron parallel heat fluxes and ion to electron energy transfer rate are also presented as a function of those plasma control parameters. To establish trends in the dependence of Ti/Te on the collisionality, a dimensionless comparison is studied across devices among the tokamak divertor configurations, EAST and WEST, and the stellarator island configuration, W7-X[1]. The results show that Ti/Te gradually decreases from ~3 to ~1 as the normalized ion collisionality increases from ~10 to ~100. These trends are hardly changed despite their quite different magnetic configurations.

To understand the SOL ion and electron energy balance, the HESEL model [2] is introduced to reconstruct the probe measurement and predict the relationship between Ti/Te and collisionality near the separatrix. The simulated dependence of Ti/Te on the collisionality is quantitatively consistent with the experimental measurement, while near the separatrix the Ti/Te has a weak dependence on the collisionality. This difference indicates that the conduction and advection ratio might play the dominant role over the magnetic topology effect on the ion and electron energy balance.

This work is thought to provide helpful information for our overall understanding of SOL and Divertor physics and modeling and for divertor heat flux dissipation.

References

a See appendix in B.N. Wan et al 2019 Nucl. Fusion 59 112003;
b See http://west.cea.fr/WESTteam;
c See the author list in T. Klinger et al 2019 Nucl. Fusion 59 112004;