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Understanding the upstream ion and electron temperature ratio evolution in the scrape-off layer of both WEST and W7-X

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This work reports the upstream ion and electron temperature ratio (Ti/Te) evolution in both the scrape-off layer of the WEST standard divertor and the W7-X island divertor geometry[1,2]. A universal dependence between the Ti/Te ratio and the normalized ion collisionality was uncovered in the WEST's near and far SOL region, and this dependence also exists in the W7-X's island region with density gradient direction the same with the WEST's. The upstream Ti/Te ratio tendency gradually decreases from ~3 to ~1 as the normalized ion collisionality increases from ~5 to ~100. While inside the island region with density gradient reversed with the WEST's, the Ti/Te ratio is enhanced. This result is shown in Fig. 1.

A theoretical analysis reveals that there exists a general equation to describe the Ti/Te ratio for both WEST and W7-X. The result shows that increasing the perpendicular transport factor will hardly increase the Ti/Te ratio when $(\eta i+1)/(\eta e+1)>0$, while will significantly enhance the Ti/Te ratio when $(\eta i+1)/(\eta e+1)<0$, which is corresponding to reversed density gradient. The minor increase is probable because that the ion and electron parallel heat conduction ratio is predominant in determining this universal dependence, while the perpendicular ion and electron heat transport ratio (one order smaller than the parallel's) slightly impact the Ti/Te ratio. The significant enhancement of the Ti/Te ratio maybe attributed to the asymmetric energy transfer from electrons and ions to the neutral particles. Because the residual island region accumulates a large amount of neutral particles, not only a peak density structure is appeared near the iota=1 surface, but also the electrons transfer much larger energy than the ions to the neutral particles, leading to higher Ti/Te ratio in this region. This work may be helpful to understand the ion and electron energy equilibration in SOL for future fusion devices. This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 and 2019-2020 under grant agreement No 633053, and was supported by the National Natural Science Foundation of China under Grant Nos. 11705237.

References

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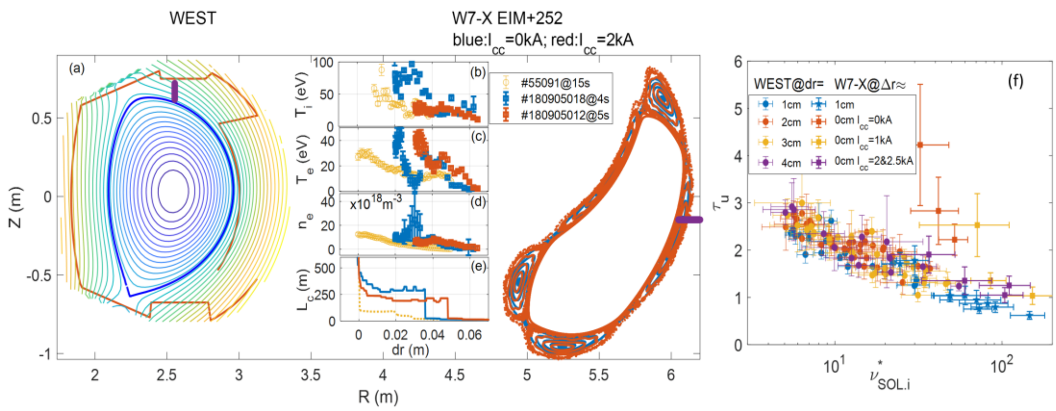

Figure 1. (a) Magnetic configuration for WEST and W7-X. The probe measurement paths are shown as the purple line both in WEST and W7-X. Embedded sub-figures from up to bottom are the profiles of (b) ion and (b) electron temperatures, (c) electron density and (d) magnetic connection length at the probe paths. (f) Ion to electron temperature ratio (Ti/Te) as a function of normalized ion collisionality for WEST and W7-X.