Turbulent transport versus density gradient: an inter-machine study with the gyrokinetic code `stella`

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It has been experimentally observed in both tokamaks [1,2] and stellarators [3,4,5] that peaked density profiles lead to a reduction of turbulent transport, which is believed to be related to the stabilization of ion-temperature-gradient-driven turbulence. In this conference contribution, we perform gyrokinetic simulations at ion Larmor scales with the gyrokinetic code `stella` [6] focusing on the effect of the density gradient on nonlinear heat fluxes. The influence of the magnetic geometry is investigated by means of an inter-machine study that includes the W7-X, LHD, TJ-II and NCSX stellarators, as well as the ASDEX Upgrade and Cyclone Base Case (CBC) tokamaks [7]. In [8], a preliminary version of the results, setting the electron temperature gradient to zero, was reported. Here, the results are extended to include the effect of a finite electron temperature gradient, equal to the ion temperature gradient. The simulations are collisionless and consider kinetic electrons.

The ion heat flux is computed as a function of the normalized density gradient, scanned from $a/L_n=0$ up to $a/L_n=4$, for a fixed value of the normalized ion temperature gradient, $a/L_{Ti}=3$. As shown in [8], for a broad range of the scanned a/L_n values and for a vanishing electron temperature gradient, W7-X and NCSX exhibit a strong reduction of the ion heat flux with increasing a/L_n. In TJ-II the reduction is more modest and in LHD the ion heat flux has a weak dependence on a/L_n. In contrast to the stellarators, the ion heat flux of the ASDEX Upgrade and CBC tokamaks increases strongly with the density gradient, up to density gradients of $a/L_n=2.5$ and $a/L_n=3$, respectively, after which the ion heat flux decreases substantially in ASDEX Upgrade, and moderately in CBC. In the presence of a finite electron temperature gradient, $a/L_{Te}=3$, the ion heat flux is increased substantially for the tokamaks, while for the stellarators it remains approximately the same as in the case with a zero electron temperature gradient. Finally, we discuss the electron heat flux. We will argue that it is dominated by ion-scale turbulence and show that, unsurprisingly, it increases significantly for all devices of this study when considering a non-vanishing electron temperature gradient.

References

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