Turbulent heat flux 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 enhanced confinement regimes. The reduction in transport is believed to be related to the stabilization of ion-scale turbulence. In this conference contribution, we perform gyrokinetic simulations 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 Cyclone Base Case tokamak [7]. The simulations are collisionless and a vanishing electron temperature gradient is assumed.

The main result of this work is shown in Fig.1 (right). For the devices listed above, we have computed the ion heat flux as a function of the normalized density gradient, a/L_n, for a fixed value of the normalized ion temperature gradient, $a/L_{Ti}=3$, by means of nonlinear `stella` simulations with kinetic electrons. We show that, in a broad range of the scanned a/L_n values, 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, we have found that the ion heat flux of the tokamak (not shown in the figure) increases strongly with the density gradient. By comparing Fig.1 (left) and Fig.1 (right), it is clear that, in stellarator geometry, the behavior of the linear growth rates as a function of a/L_n does not correlate with the behavior of the ion heat flux. Finally, in this conference contribution we will also discuss the effect on the ion heat flux of treating the electrons adiabatically or kinetically, as well as the effect of taking zero or finite a/L_{Ti}.

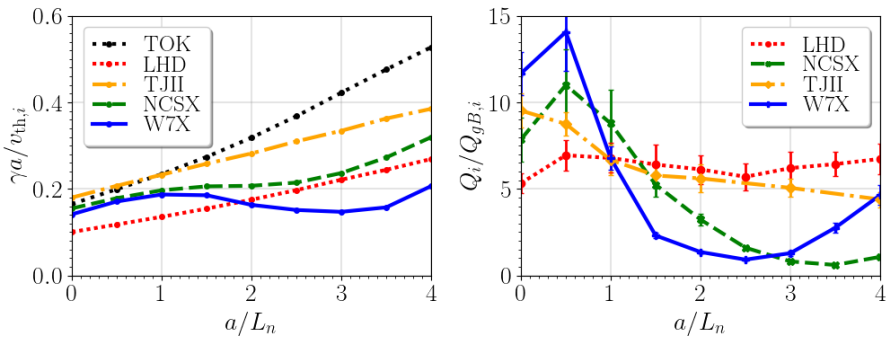

Figure 1: *Growth rates of the most unstable mode (left) and ion heat fluxes (right) as a function of a/L_n at fixed $a/L_{Ti}=3$ for the devices listed in the text. The ion heat fluxes of the tokamak are not visible since its values lie above the displayed range.*

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