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How non-adiabatic passing electron dynamics and density of mode rational surfaces affect turbulent transport in magnetic fusion plasmas

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The non-adiabatic response of passing electrons near low order Mode Rational Surfaces (MRSs) leads to fine radial structures on ion-scale microinstabilities (Ion Temperature Gradient and Trapped Electron Mode instabilities). It has been shown that these structures persist in the non-linear turbulent regime driven by these instabilities and lead to the corrugation of radial density and temperature profiles, as well as zonal flows. This effect may significantly affect the turbulent fluxes of heat and particles as was shown using both local (flux-tube) and global gyrokinetic simulations [1,2]. It is indeed well known that the shearing rate associated to zonal flows plays an important role in regulating transport levels. The generation of fine zonal flow structures centered at lowest order MRSs, which are separated by a distance $L_{LMRS} = r_0 / n_{min} q_0 s$ (where s is the magnetic shear, n_{min} the minimum considered toroidal mode number and q_0 the safety factor at a given radial position r_0), leads to higher time averaged shearing rates at these radial positions. By varying n_{min} or the magnetic shear s one can vary L_{LMRS} and therefore the density of zonal flow shearing layers associated to lowest order MRS. Using the flux-tube version of the gyrokinetic code GENE, we show that through this mechanism, turbulent transport tends to increase with decreasing density of lowest order MRSs.

References

[1] J. Dominski, et al., Physics of Plasmas 22, 062303 (2015)
[2] J. Dominski, et al., Physics of Plasmas 24, 022308 (2017)