Microtearing turbulence and reduced transport model building in H-mode plasmas

M.Hamed[1], M.J. Pueschel[1,2], and J. Citrin[1]

[1] *Dutch Institute for Fundamental Energy Research, 5612 AJ Eindhoven, The Netherlands*

[2] *Eindhoven University of Technology, 5600 MB Eindhoven, The Netherlands*

In many fusion plasmas, microtearing turbulence is a key player, covering core and edge/pedestal scenarios as well as spherical tokamaks. Recent analysis of JET plasmas [1] suggest that microtearing (MT) mode, may be responsible for electron heat transport in the pedestal, and thereby play some role in determining the pedestal characteristics. The stability of MT modes has been extensively studied, showing that a slab current sheet is stable in the absence of collisions [2, 3, 4]. In contrast, recent gyrokinetic simulations in toroidal geometry found unstable MT modes [5, 6], even at low collisionality.

To predict the electron heat transport due to MT in a tokamak pedestal, and to aid with the development of a quasilinear MT transport model, nonlinear simulations were run with the GENE code and analyzed with respect to magnetic fluctuations and the question which kind of physics sets the saturation amplitudes in the quasi-stationary turbulent state. This is a key prerequisite for developing a reduced MT model applicable for flux-driven integrated modeling. A reduced model for microtearing transport is presented that reproduces gyrokinetic trends for a number of parameter regimes, as is demonstrated by comparison with a database of nonlinear gyrokinetic simulations. Using this model, the impact of different physical parameters, in particular the electric potential, has been investigated in nonlinear saturation. The electric potential play an important role in microtearing destabilization by increasing the growth rate of this instability in the presence of collisions, while in electrostatic plasma micro-turbulence, zonal flows can have a strong stabilizing impact in turbulent saturation. Here, instability and saturation physics are examined for different pedestal cases and radial positions, with a special focus on the role of electric field fluctuations and the role of zonal flows and fields. In the saturated state, it is found that removing the zonal flow and zonal fields causes a flux increase, while linearly stabilization had been observed. This model will be coupled to a neural network for sweeping parameter scans, working towards real-time transport modeling in particular of the tokamak pedestal.

References

[1] D.R. Hatch *et al.*, *Nucl. Fusion* **56**: 104003 (2016).

[2] R. D. Hazeltine, D. Dobrott, and T.S. Wang, *Phys. Fluids* **18**: 1778 (1975).

[3] M. Hamed, M. Muraglia, Y. Camenen, and X. Garbet, *Contrib. Plas. Phys.*, 58: 529-533 (2018)

[4] M. Hamed, M. Muraglia, Y. Camenen, and X. Garbet, *J. Phys.: Conf. Ser.* **1125**: 012012, 2018

[5] A.K. Swamy *et al*, *Phys. Plasmas* **21**, 082513 (2014).

[6] D. Dickinson *et al*, *Phys. Rev. Let.* **108**, 135002 (2012).

[7] M. Hamed, M. Muraglia, Y. Camenen, X. Garbet, and O. Agullo, Physics of Plasmas, 26(9):092506, 2019.