Particle Transport Response To Dynamical Density Gradients As A Function Of Magnetic Well In The TJ-II Stellarator

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Determining the relation between free energy sources such as the density gradient and the induced transport is fundamental for an improved understanding of systems far from equilibrium such as fusion plasmas. Recently, a statistical approach to this issue was reported, using measurements in the plasma edge of magnetically confined fusion devices [1] showing that the size of turbulent events is minimum in the proximity of the most probable gradient and suggesting the importance of plasma transport and gradient self-regulation mechanisms

Stellarators have the advantage of offering strict external control of the magnetic configuration, while TJ-II in particular is characterized by significant configurational flexibility. We exploit this feature to investigate the dynamical flux-gradient relation as a function of magnetic well in the plasma edge region. Theoretically, a reduced value of the magnetic well should lower the threshold of certain MHD instabilities. For this purpose, we have successfully created reproducible Neutral Beam Heated (NBI) heated plasmas, even with low or near zero magnetic well in the edge.

Like the earlier results [1], we show that the statistical mean flux-gradient relation exhibits a minimum at the most probable (mean) gradient which is generally asymmetric, producing a larger flux for negative gradient excursions (steeper profiles) than for positive ones (gentler profiles). We also show that the mean flux depends both on the magnetic well and the mean density (i.e., the mean driving gradient). As the magnetic well is reduced, the mean fluctuating flux increases while fluctuating gradient excursions remain virtually constant.

We also report on the implications for causality [2], showing that in strongly driven plasmas the flux is driving the gradient fluctuations in the edge plasma, rather than vice versa.

[1] C. Hidalgo, C. Silva, B.A. Carreras, B. van Milligen, H. Figueiredo, L. García, M.A. Pedrosa, B. Gonçalves, and A. Alonso, *Dynamical coupling between gradients and transport in fusion plasmas*, Phys. Rev. Lett. 108 (2012), 065001

[2] B.Ph. van Milligen, G. Birkenmeier, M. Ramisch, T. Estrada, C. Hidalgo, and A. Alonso, *Causality detection and turbulence in fusion plasmas*, Nucl. Fusion 54 (2014), 023011