On the physics of shear flows in 3-D geometry

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The discovery of the transition to edge improved confinement regimes at the beginning of the 1980's brought on a new era in magnetic confinement fusion. After more than 25 years of active research, most experimental evidences support the paradigm of sheared electric field suppression of turbulence to explain pedestal transport, although the underlying mechanisms that generate the electric fields still remain as the fundamental open issue confronting the fusion community. As pedestal plasma parameters have a strong impact on global confinement, prediction of the ITER pedestal parameters and the H-mode transport barrier width remain a key and fully open research area. Indeed, large uncertainties are still present in the empirical description of the L-H transition power threshold, with significant implications for the overall structure of the ITER research plan.

Critical test of models for transport barriers based on second order (turbulent driven flow) and first order (pressure gradient driven flows) phase transition as well as role of equilibrium flows and the neutral physics are needed for the development of a comprehensive theory of the L-H transition and transport barriers. In the case of edge transport barriers, the influence of plasma boundary conditions on empirical power threshold should be also addressed. Due to the times/spatial scales involved this research area is a real challenge for both theorists and experimentalists.

Recent experiments have shown the importance of multi-scale (long-range) mechanisms in the transition to improved confinement regimes and the key role of electric fields to amplify them [1]. Flows driven by turbulence might explain such experimental observation, which would imply to consider the importance of 3-D effects on the energy transfer between flows and turbulence. Comparative studies in different magnetic configurations (tokamak vs stellarators), diagnostic development and large-scale simulation are needed to assess the importance of multi-scale physics in the development of sheared flows.

[1] M. A. Pedrosa, C. Silva, C. Hidalgo et al., Phys. Rev. Lett. **100**, 215003 (2008).