Gyrokinetic simulations on the triggering and self-sustaining of internal transport barrier in HL-2A tokamak plasmas

W. H. Lin[1], J. Garcia[2], J. Q. Li[1], S. Mazzi[2], Z. J. Li[1], X. X. He[1] and X. Yu

[1] *Southwestern Institute of Physics, Chengdu 610041, China.*

[2] *CEA, IRFM, F-13108 Saint Paul-lez-Durance, France.*

Internal transport barriers (ITB) [1], characterized by steep pressure gradients and high temperatures and densities near the core region of tokamak, provide a promising way to the reduction of energy loses and improvement of plasmas confinement. To clarify the obscure aspects that remain in our knowledge of ITB formation, the state-of-the-art gyro-kinetic code GENE [2] is utilized to perform non-linear simulations for the ITB discharge #22453 [3] in HL-2A tokamak. A new paradigm for the ITB formation is proposed in which different physics mechanisms play a different role depending on the ITB formation stage. It is confirmed that the fast ion dilution effect, arising from increase of fast ion fraction due to Neutral Beam Injection (NBI), is capable of stabilizing the Ion Temperature Gradient (ITG) modes, reducing the ion fluxes to a low value and finally triggering ITB in HL-2A. However, such a mechanism plays a minor role once ITB is fully formed. We define the concept of ITB self-sustainment, as the ITB is supported by an interplay of zonal flows and electromagnetic modes with low toroidal number in the presence of finite- and steep pressure gradients once the ITB is triggered. Unlike turbulent transport reduction by $E \times B$ shearing, which is not found to play a role on the ITB formation in our work, the mechanism found in this study could be important in future tokamak devices as long as finite-β effects are strong enough.

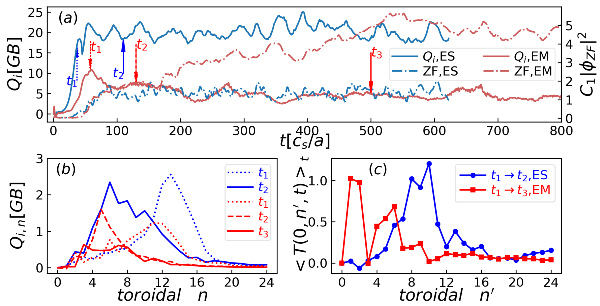

Figure 1: *(a) Time trace of the total ion fluxes and zonal field energy for the electromagnetic (EM) and electrostatic (ES) case. (b) Flux spectrum at the normalized time marked in (a). (c) Time-averaged nonlinear contribution to the growth of ZF energy*

References

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