Suppression of ion-scale turbulent transport by MeV-range fast ions at JET

S. Mazzi[1,2], J. Garcia[2], D. Zarzoso[1], Y. Kazakov[3], J. Ongena[3], M. Nocente[4,5], M. Dreval[6], Z. Stancar[7], G Szepesi[8] and JET contributors[a]

[1] Aix-Marseille Université, CNRS PIIM, UMR 7345 Marseille, France
[2] CEA, IRFM, F-13108 Saint-Paul-lez-Durance, France
[3] Laboratory for Plasma Physics, LPP-ERM/KMS, TEC Partner, Brussels, Belgium
[4] Dipartimento di Fisica "G. Occhialini", Università di Milano-Bicocca, Milan, Italy
[5] Institute for Plasma Science and Technology, National Research Council, Milan, Italy
[6] National Science Center Institute of Physics and Technology, Kharkiv 61108, Ukraine
[7] Jožef Stefan Institute, Jamova cesta 39, SI-1000 Ljubljana, Slovenia
[8] CCFE, Culham Science Centre, Abingdon, Oxon, OX14 3DB, United Kingdom
[a] See the author list of E. Joffrin et al., Nucl. Fusion 59, 112021 (2019)

Assessing the impact of fusion-born alpha particles on turbulent transport is of prime importance, as future tokamak devices will be heated by the alpha power. However, in present day experiments this issue has not been explicitly studied, and thereby highly energetic alpha particles may lead to unexpected transport regimes in future D-T plasmas. Hence, developing experimental scenarios which can mimic ITER conditions is an imperative.

Recent insights have been provided in ITER-relevant plasmas at JET [1], where a significant population of MeV-range fast ions mimicking alphas' energy is generated by using the advanced 3-ion ICRF scheme [2]. Rather surprisingly, these plasmas present an improvement of the bulk-ion confinement, despite the strong excitation of a rich variety of Alfvén Eigenmodes (AEs) and the dominant collisional electron heating in the core due to the MeV ions [3]. In order to gain detailed physical insights, demanding nonlinear gyrokinetic analyses with the state-of-the-art GENE code [4] are performed. In this framework, solving self-consistently both large MeV- and bulk-ion scales and their possible cross-interactions is essential to discern the possible effect of the MeV ions on the ITG-driven turbulent transport. Thus, for the first time in realistic validation studies, the role of fully destabilized AEs is proved to be crucial for ITG transport reduction. A complex multi-scale interplay involving zonal shearing flows, nonlinearly triggered by fast-ion-driven TAEs, is shown to be the underlying mechanism for the ion-scale turbulence suppression [5]. Indeed, both electrostatic and electromagnetic zonal components are highly enhanced through nonlinear coupling with the large TAE scale. Moreover, the analysed phase de-correlation of the fluctuating physical parameters driving the particle and energy fluxes represents a clear evidence of the zonal shearing effects on the bulk-ion microturbulence.

In conclusion, such a beneficial mechanism, driven by the presence of MeV-range ions, paves the way towards an efficient exploitation of future fusion devices with dominant alpha-particle heating, such as ITER.

[1] Y. Kazakov *et al.*, *Nucl. Fusion* **60**, 112013 (2020)

[2] Y. Kazakov *et al.*, *Nat. Phys* **13**, 973-978 (2017)

[3] M. Nocente *et al.*, *Nucl. Fusion* **60**, 124006 (2020)

[4] F. Jenko *et al.*, *Phys. Plasmas* **7**, 1904-1910 (2000)

[5] S. Mazzi *et al.*, *Submitted to Nat. Phys.* (2020)