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Turbulence Suppression by MeV-Range Fast Ions at ITER-Relevant Conditions in the JET Tokamak[1]

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Recently, JET has realized an ITER-relevant scenario with a sufficiently large population of MeV-range ions, exciting a variety of Alfvn Eigenmodes (AEs), by using the innovative 3-ion ICRF heating scheme [J. Ongena et al., EPJ Web. Conf. 157, 02006 (2017)]. Despite the presence of strong AE activity, a significant improved thermal ion confinement was observed. By means of the state-of-the-art gyrokinetic code GENE [F. Jenko et al., Phys. Plasmas 7(5), 1904 (2000)], it is shown that, unlike previous studies in JET with less energetic fast ions [J. Citrin et al., Phys. Rev. Lett. 111, 155001 (2013), J. Garcia et al., Nucl. Fusion 55, 053007 (2015)], the ITG-driven electrostatic transport is totally suppressed in the presence of a large MeV-range fast-ion population. Realistic nonlinear electromagnetic simulations with three ion species and kinetic electrons are presented to unveil a complex interplay between AEs and nonlinearly generated zonal flows. Evidences of such an interplay rely on the enhancement of ZF shearing concurrently with the onset of the fast ion electrostatic energy flux, and it is thereby envisaged to be the underlying mechanism for the reduction of the ion-scale microturbulence. In these conditions, the magnetic fluctuations dominate the thermal turbulent transport, leading to a pure magnetic system in which the fast-ion transport is dominant. Extended studies show that negative magnetic shear further reduces such fast ion transport by stabilizing TAEs. In turn, this has led, for the first time on JET, to an optimum plasma state where both thermal and fast ion transport are reduced.

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