Fast ions as a source of transport suppression in JET plasmas.

J. Garcia and JET contributors*

CEA, IRFM, F-13108 Saint-Paul-lez-Durance, France.
(*) See the author list of Joffrin E. et al 2019 Nucl. Fusion 59 112021

From 2010, plasmas with high energy confinement have been obtained at JET in conditions of high core beta, pressure gradients and fast ions population [1-4]. A close link between experiment and HPC has been stablished at JET in the period 2010-2020 with the aim of unveiling if new physical mechanisms were responsible for turbulence modification and transport reduction in such conditions. For that purpose, high quality experimental data was used for detailed and complex gyrokinetic simulations mostly performed with the GENE code [5] with up to 12000 cores. Initial results clearly indicated a strong impact of pressure gradients, notably from fast ions, on thermal ion heat transport reduction in high beta plasmas [6,7]. Such reduction is one of the causes of the low degradation of energy confinement with input power obtained in dedicated JET experiments [8].

One elusive point in these initial results was the physical mechanism behind turbulence reduction on the ion gyroradious scale. Alfvén Eingemodes (AE) were pointed out to play a role by boosting zonal flow activity able to reduce ion scale transport [9]. Recent experiments at JET have been able to provide further evidence by using ICRH heating with three ions scheme [10], which provides a significant amount on MeV ions. In such conditions, strong AE activity in improved confinement plasmas is obtained. Detailed HPC analyses with GENE show that MeV ions trigger nonlinearly large-scale zonal flows both in the electrostatic and electromagnetic potentials able to suppress electrostatic transport and leaving electromagnetic fluctuations as the main source of weak electron transport [11]. These results have strong implication for the D-T operation in ITER. In the presence of energetic fusion born alpha particles, AE activity may lead to ion transport suppression therefore increasing ion thermal energy, which in turn generates more alpha power in a virtuous cycle. Such possibility will be studied first in the upcoming JET DT campaign [12].

[1] J. Garcia et al., PRL 104, 205003 (2010) [2] J. Garcia et al 2013 Nucl. Fusion 53 043023 [3] P. Mantica et al. PRL 102, 175002 (2009) [4] P. Mantica et al., PRL 107, 135004 (2011) [5] F. Jenko et al., Physics of Plasmas, 7(5):1904–1910, 2000 [6] J. Citrin et al., PRL 111, 155001 (2013) [7] J. Garcia et al 2015 Nucl. Fusion 55 053007 [8] C.D. Challis et al 2015 Nucl. Fusion 55 053031 [9] A. Di Siena et al 2019 Nucl. Fusion 59 124001 [10] Y.O. Kazakov et al., Nature Physics, 13(10):973–978, 2017 [11] S. Mazzi et al., submitted to Nature Physics [12] J. Garcia et al Nucl. Fusion 59 (2019) 086047