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New fast ion physics routes opened in D-^{3}He plasmas of the Joint European Torus and implications for alpha particle physics studies in deuterium-tritium

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Alpha particle physics studies are among the aims of the forthcoming deuterium-tritium (DT) campaign at the Joint European Torus (JET). On one hand, there is need to unambiguously document the contribution of alpha particles to plasma heating as their fraction progressively increases. On the other hand, effort is being put on the development of a dedicated - so called "after-glow" - scenario [1] that can excite toroidal Alfven Eigenmodes (AE) driven by the alpha particles in DT.

Recent experiments on the development of the three Ion Cyclotron Resonance Heating (ICRH) scheme [2] in D-^{3}He plasmas have however opened new, alternative routes for the investigation of MeV range, fast ion physics at JET, both in deuterium and DT, and are here presented. In particular, we focus on a proof of principle experiment where alpha particles are generated in JET D-^{3}He plasmas using the ^{3}He(d,p)α reaction in lieu of t(d,n)α as in DT and with a suitable three ion scheme [3]. In the experiment a combination of ICRH and neutral beam injection (NBI) heating are used to accelerate D-NBI ions to energies ranging between hundreds of keV to some MeVs, which allows controlling the alpha particle yield from ^{3}He(d,p)α at the level of 10^{16} particles/s. This is measured by a number of new fast ion diagnostics that can also provide, for the first time, a spatial image of the alpha particle source through gamma-ray emission. Of special note are here the peculiar features that these plasmas have and that seem to anticipate some of the effects expected from alpha particles in DT. Despite a predominant electron heating, we observe $T_i \approx T_e$ in all the discharges, pointing towards a reduction of turbulence by the fast ions, which allows for an effective equipartition of energy between the electron and ion populations. All these plasmas further display a large variety of AEs, including unexpectedly unstable reversed shear AEs, which suggest that a q-profile reversal is achieved in steady state conditions. When the NBI is switched off, thereby mimicking an "after-glow" scenario to study the slowing down of the MeV range D and alpha particle populations, we observe long lived elliptic AEs that remain unstable for more than a second within the "after-glow" phase. Simulations to understand the excitation conditions of these modes are being made to clarify the contribution of the fusion born alphas to the drive of the instabilities, as this may provide an alternative scenario to the observation of alpha driven AEs in DT.

Finally, we discuss the implications of these results to the understanding of alpha particle effects in JET and ITER and, more generally, the potentials offered by three ion scheme scenarios for this type of studies in DT plasmas.

References

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