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Alpha particle physics studies in JET D-^{3}He plasmas in preparation for D-T[1]

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We report results of studies in D-^{3}He plasmas on JET ($n(^3\mathrm{He})/n_\mathrm{e}$ ≈20-25%) using the 3-ion radio frequency (RF) scheme [1, 2] for the core acceleration of deuterons from neutral beam injection (NBI) to higher energies to generate alpha particles from D+^{3}He fusion reactions. The fast-ion distribution of RF-accelerated D-NBI ions was controlled by varying the RF/NBI power ratio (P_RF ≈4-6MW, P_NBI ≈3-20MW). With as little as P_RF ≈6 MW and P_NBI ≈7-10 MW, rather high D-D neutron (≈1x10^{16} 1/s) and D-^{3}He alpha rates (≈210^{16} 1/s) were achieved. For the first time in JET-ILW, the upgraded gamma-ray diagnostic [3] provided spatial images of the alpha birth profile, validating this essential diagnostic for its use in future D-T experiments. Dominant fast-ion heating and a rich variety of fast-ion driven Alfvén eigenmodes (AEs) were observed in these discharges, which allowed mimicking several aspects of future burning plasmas, where alphas will largely affect heating and global confinement. The sawtooth period in D-^{3}He pulses on JET varied between ≈200-300 ms and 3.9 s, depending on the RF/NBI power ratio, n_e, etc. During long period sawteeth (>≈1s), reversed shear AEs were additionally detected by magnetic coils. This indicates that a non-monotonic q-profile was developed and sustained by large fast-ion populations. AE dynamics were different in pulses with short sawteeth periods. In these conditions, $n = 0$ global AEs were regularly observed, hinting at the presence of fast ions with an inverted distribution. The possibility that some of the observed AEs were driven by fusion-born alphas is under investigation. Surprisingly, this complex AE activity is not detrimental for the thermal confinement, which is actually enhanced in the inner core, especially for the ions. [1] Kazakov, Y *et al. Nature Phys* **13,** 973–978 (2017) [2] Ongena, J *et al. EPJ Web of Conferences* **157**, 02006 (2017) [3] Rigamonti, D *et al. Rev. Sci. Instrum.* **89**, 10I116 (2018)

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