Electron Density Peaking Induced by Neon seeding in JET Hybrid Plasmas

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Gyrokinetic analysis shows that light impurities in sufficient concentrations can drive a turbulent flux of fuel particles and electron much larger than the neoclassical pinch [1,2]. The effect of neon on electron density peaking has been studied systematically on a set of JET hybrid discharges and compared with theory and modelling predictions. The database analysed here includes around 20 hybrid discharges at I_P = 1.4 MA, B_T= 1.9 T, β_N = 2.2, additionally heated by 16.5 MW of Neutral Beam Injection power (NBI). Three of the above discharges had a small amount (< 1 MW) of Ion Cyclotron Resonance Heating (ICRH). Neon was injected at the start of the NBI heating phase and it was already present during the transition to H-mode: when the central density had reached its top value (≈ 4 s later) the neon contribution to the total number of injected electrons ranged from 5% to 40%. Un-seeded reference discharges were also performed with the same engineering parameters. In the seeded discharges, the core density profile peaking, defined as the ratio between the central (ρ=0.25) and the pedestal density, increases up to $n_{peak/core}$ ≈ 2 depending on the amount of injected neon. Interestingly, in this database, the density peaking increases with the average collisionality as shown in Figure 1. This goes in the opposite direction of the trend described in [3] for un-seeded discharges. No clear evidence of core impurity accumulation was found able to justify the observed electron density peaking. Fully predictive transport simulations have been carried out with the JETTO code. The introduction of an inward particle pinch proportional to the neon concentration and grad T_i, in addition to the neoclassical and Bohm/gyro-Bohm transport was needed to reproduce the data. The inward particle flux generated by the neon doping reduces the overall diffusive/convective flux of both neoclassical and turbulent nature that balances the beam particle source. The JETTO analysis has been repeated with the QualiKiz transport model and integrated with nonlinear gyrokinetic simulations.

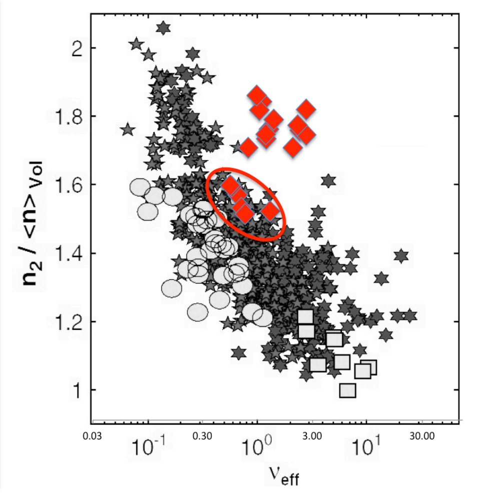

Figure 1. Density peaking versus collisionality (database of ref. [3]). Red diamonds are values from the neon-seeding scan. Points encircled from reference and low seeding discharges.

[1] M. Romanelli et al., Nucl. Fusion 51 (2011) 103008 [2] G. Szepesi et al., Nucl. Fusion 53 (2013) 033007
[3] C. Angioni et al., Nucl. Fusion 47 (2007) 1326–1335