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Neutral Beam Heating on the TCV Tokamak

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TCV's principal goal is to explore and develop the physics basis for ITER exploitation and to aid in the development of DEMO. In the initial design, a combination of X2 and X3 ECH power was planned and installed to provide precision auxiliary heating. With a nominal <1.5T toroidal field strength, X2 heating remains limited to electron densities <˜4e10ˆ19/m3 and X3 to electron densities below ˜10ˆ20/m3. Several realms of plasma operation, pertinent to our stated goals of ITER and DEMO relevance, remained, however, only marginally accessible. When ECH power alone heats the plasma, electron-ion collisional equipartition decreases resulting in extremely hot electrons with the ion temperature trailing, on TCV, by a factor that can exceed 30. For all these reasons, a phased upgrade program [A.Fasoli and S.Coda at this conference] is underway on TCV that not only extends the power range of X2 and X3 heating but also introduces direct ion auxiliary heating using state of the art Neutral Beam Injection. In a first stage, (scheduled for final acceptance early in 2016), a 1MW tangentially launched neutral beam of Hydrogen or Deuterium is installed and reported in this paper. By ion dominated heating at sufficient densities (>5x10ˆ19/m3) that increases collisional electron heating, efficient X3 power deposition also becomes possible. To harness this effect, part of the future upgrades, envisage some X3 power launched through the lateral launchers where, with sufficient electron temperature (>2keV), precision X3 deposition, similar to X2 heating today, becomes available, but at higher electron densities.
This paper concentrates on a comparison between the modelled and experimentally observed plasma behaviours and improved access to reactor relevant regimes. Models predict Ti/Te ratios above 3 in L-mode and slightly less in H-mode with one beam and X2(L-mode) or X3(H-mode). With an eye to the future, with the planned increase in ECH power and the second counter injected beam, ion-electron temperature equalisation with βN >2.8 is expected. This combination of a large electron heating power density and sufficient ion heating to achieve Ti/Te˜1 will make TCV plasmas unique. Discharges with a highly non-thermal electron distribution together with those with a strong fast ion component, both relevant to reactor scenarios, become possible.

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