Abstract for an Invited Paper
for the DPP07 Meeting of
The American Physical Society

Effects of toroidal field ripple on H-modes in JET and implications for ITER operations

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The effects of toroidal field ripple (dB) on H-mode confinement are not well understood and were not included in the criteria for the design of the ITER toroidal field coil system. ITER has 18 TF coils, and dB at the plasma outer midplane separatrix position is about 1% or, with the present design of correcting ferritic inset (designed to limit first wall loads from fast ion losses), is reduced to about 0.5% at full field. Experiments were carried out in JET to study the effect of toroidal field ripple dB on ELMy H-modes confinement and pedestal parameters, as well as on ELM type and size. In the experiment, dB at the separatrix was increased to 0.3%, 0.5%, 0.75% and 1% in separate plasma discharges, at approximately constant absorbed power. The main effect of increasing dB is a loss of plasma density (approx 30% to 40%), across the whole plasma profile, observed even at the minimum dB. The H-mode enhancement factor is reduced by up to approximately 20% at 1% ripple compared to reference (dB=0.08%). VTOR decreases by a factor of 4 in the pedestal region when dBgoes from 0.08% to 0.5% At higher dB, VTOR at the plasma edge goes to zero and eventually becomes negative (dB =1%). The H-mode density can be increased by external gas puff and the response of the density to external fuelling is similar for plasmas with and without ripple. Ripple also affects Type I ELM behavior. For plasmas without external gas fuelling, the ELM energy loss is smaller by a factor of 2 with 1% ripple compared to the reference case, due to a reduction of the prompt temperature drop at the ELM. The confinement degradation and loss of density may have worrying implications for the performance of the ITER baseline scenario. The extrapolation of JET results to ITER and possible design solutions for further reduction of dB in ITER will be discussed.