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EX/P4-31: Addressing New Challenges for Error Field Correction

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The correction of error fields in ITER is found to be far more challenging than previously thought due to the effects of a multi-component response to such fields at multiple surfaces in the plasma. This situation is exacerbated by an amplification of error fields in H-modes, where a developing resistive response is observed, with fields found to brake plasma rotation and destabilize intrinsic m=2, n=1 tearing instabilities. New scalings of mode-trigger thresholds were obtained from this process, and are compared with new Monte Carlo calculations of the error fields expected in ITER, updated for the ideal-response formalism by which the error fields couple to the plasma. These indicate that correction will need to reduce error fields by ~50% to avoid instability in the ITER baseline. This is comparable to the best levels of correction presently achievable in devices around the world. Obtaining this level of correction typically requires well-optimized dual toroidal array dual arrays, usually located close to the plasma. Experiments have explored this physics using large amplitude proxy error fields with a known controllable field structure. These confirm the limitations and indicate that they arise within n=1 field components, rather than higher toroidal mode number, or inherent stability or control limits. This indicates that the fields must couple to the plasma though multiple ideal mode, and that once in the plasma, must interact at more than one resonant surface or non-resonantly. Modeling with the IPEC code favors the latter interpretation with a decrease in resonant fields being accompanied by an increase in NTV damping. Further results using an optimized 'ideal-mode'structured correction field, yield little improvement over standard error field correction, also favoring a non-resonant interpretation of the residual field effects. These results indicate that ITER needs to have sufficient harmonic flexibility to adapt to the underlying error field, cancelling it at more than one surface in the plasma, and preferably near its source. Thus it should consider a multi-harmonic error field correction strategy, and may need to additionally deploy its ELM control coils for error correction, to ensure disruption free operation.

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