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The impact of anisotropy on ITER scenarios and Edge Localised Modes

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We report on the impact of anisotropy and flow to tokamak plasma configuration and stability in several different regimes.

First, we conduct a preliminary analysis of the impact of anisotropy on ITER pre-fusion power operation 5MA, B=1.8T ICRH scenarios, where a RF calculation gives the fast ion distribution function. To model ITER scenarios remapping tools are developed that iterate the anisotropy-modified current profile to produce the same q profile with matched thermal energy. We find characteristic detachment of flux surfaces from pressure surfaces, and an outboard (inboard) shift of peak pressure $T_{||} > T_{\perp}$. Differences in the poloidal current profile are evident, albeit not as pronounced as for the spherical tokamak. We find that the incompressional continuum is largely unchanged in the presence of anisotropy, and the mode structure of gap modes is largely unchanged. The compressional branch however exhibits significant differences in the continuum. We report on the implication of these modifications, and scan over a wider set of ITER scenarios.

Second, we explore the impact of anisotropy on ballooning mode, one of the instabilities believed to be responsible for ELMS. The investigation was conducted using the newly-developed codes HELENA+ATF[1] and MISHKA-A[2], which adds anisotropic physics to equilibria and stability analysis. We have examined the impact of anisotropy on the stability of an $n = 30$ ballooning mode, confirming results conform to previous calculations in the isotropic limit. Growth rates of ballooning modes in equilibria with different levels of anisotropy were then calculated using the stability code MISHKA-A. The key finding was that the level of anisotropy had a significant impact on ballooning mode growth rates. For $T_{\perp} > T_{||}$, typical of ICRH heating, the growth rate increases, while for $T_{\perp} < T_{||}$ typical of neutral beam heating, the growth rate decreases.[3] Experimentally, values of $p_{\perp}/p_{||} >> 2.5$ and $p_{||}/p_{\perp} >> 1.7$ have been identified in JET [4] and MAST [5] plasmas, respectively. This suggests that the impact on growth rates may be significant, and indeed offer the possibility that higher ELM-free performance might be achieved by increasing $p_{||}/p_{\perp}$ in the pedestal region.

Finally, we explore the impact of toroidal flow on both the magnetic equilibrium and stability for an increasing rotation profile. We explore this for a low (n, m) modes resonant with the core plasma, and for gradually increasing rotation. This work is done ahead of benchmarking the impact of rotation on stability using the HELENA+ATF and MISHKA-A code combination.

[1] Plasma Phys. Control. Fusion 56 (2014) 075007
[2] Plasma Phys. Control. Fusion 57 (2015) 095005
[3] Plasma Phys. Control. Fusion 60 (2018) 065006
[4] Plasma Phys. Control. Fusion 43 (2001) 1441
[5] Plasma Phys. Control. Fusion 53 (2011) 074021

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