Microtearing Modes in high-β Spherical Tokamaks

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Microinstabilities often result in turbulence that influences energy confinement in tokamak discharges. One such microinstability, of particular importance to the design of next-generation spherical tokamaks (STs) such as STEP [1], is the microtearing mode (MTM), a tearing-parity mode centred on high-order rational surfaces. MTMs are short-wavelength ion scale (low $k_y\rho_s$) electromagnetic instabilities that are primarily driven unstable by the electron temperature gradient. In plasmas where β_e (the ratio of electron thermal pressure to magnetic pressure) is sufficiently high, MTMs can become the dominant instability contributing to electron transport in the plasma core, and local linear gyrokinetic (GK) simulations find that this is likely to be the case for STEP [2]. Thus, to predict the evolution of next-generation ST discharges, we must improve our capability to predict electron thermal transport driven by MTMs. A key focus for STEP is designing a reduced model for use in whole device predictive modelling codes to assist in making intelligent design choices. The first focus of this contribution will explore one promising existing model [3] and our attempts at both (i) benchmarking this model using GK simulations and (ii) generating new tools for modelling turbulence in next-generation STs. Whilst GK simulations have thus far proven to be a very accurate tool in modelling turbulent transport, obtaining saturated nonlinear MTM simulations has proven computationally challenging. Local simulations suffer from the so-called high β runaway [4], where turbulent amplitudes and transport levels grow to tremendous values once a certain β_e is exceeded. It has been a source of considerable confusion as to whether this runaway effect resulted from shortcomings of the available GK codes or due to the failure of local GK at low $k_y\rho_s$. In recent studies, global physics has been found to play a prominent role in obtaining saturated MTM simulations (e.g., [5]). In the second thrust of this contribution, we will also exploit the unique additional capabilities of the gyrokinetic code GENE [6] in our attempts to obtain the first saturated nonlinear simulations relevant to a conceptual design of a burning ST plasma.

References

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