Contribution ID: **13** Type: **Poster**

Global electromagnetic gyrokinetic simulations of TAEs in ITER

Thursday, 5 September 2019 14:30 (15 minutes)

For a long time, direct initial value gyrokinetic simulations of Alfvén eigenmodes with global structures in realistic tokamak conditions have proven very challenging. While MHD-kinetic hybrid models have been able to simulate these modes with varying reductions in the model, global gyrokinetic codes have struggled with electromagnetic simulations using realistic plasma beta and in realistic geometry. Recent work (1) has improved the mitigation of the so-called cancellation problem in electromagnetic particle-in-cell codes, allowing simulations of global large-scale modes at high plasma beta. In this work, building upon some recent developments, we present simulations performed of TAEs in the ITER 15MA baseline scenario using the gyrokinetic code ORB5 (2,3).

By starting with several simplifications to the problem, the impact of which are investigated individually, we are able to show that robust simulations can be obtained, results which we are able to compare to hybrid simulations and to linear gyrokinetic eigenvalue calculations obtained with LIGKA (4), and results which allow some limited parameter scans. Having learnt lessons from running these simplified cases, we are also able to run simulations keeping as few simplifications as possible.

With these simulations, we can study the effect of several physical processes, including the effect of the background profiles on global modes, kinetic Alfvén waves, the damping due to finite electron mass, subdominant instabilities, and the presence and interaction of modes across multiple TAE gaps with a single toroidal mode number.

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Figures 1 & 2: Snapshots of the potential for: (a) a global $n = 12$ TAE and (b) a core-localized $n = 26$ TAE. R and Z are in units of ρ_s

(1) A. Mishchenko et al. CPC 2019 (2) S. Jolliet et al. CPC 2007 (3) E. Lanti et al. CPC 2019 (submitted) (4) Ph. Lauber PPCF 2015

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Session Classification: Poster

Track Classification: Collective Phenomena