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Gyrokinetic simulations of turbulence in JT-60SA with the GENE code

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The JT-60SA[JT60SA2018] superconducting tokamak has the goal of exploring the physics basis for high-performance plasmas in ITER and DEMO. Since reactor performance is greatly limited by anomalous transport, the study of possible mitigation and control of microinstabilities, and therefore of the physics of turbulence, is paramount, as laid out by the JT-60SA research plan[JT60SA2018]. In this contribution we present a detailed linear and non-linear gyrokinetic analysis of anomalous transport in a representative JT-60SA plasma discharge that features a double-null separatrix, 41 MW of neutral beam heating and high β, the ratio of plasma kinetic to magnetic pressure. We build on the gyrokinetic simulations already performed as part of a detailed feasibility study of a Phase Contrast Imaging system[Coda1992] on JT-60SA.

Local gyrokinetic simulations are carried out with the GENE code [Jenko2000, Goerler2011] considering realistic kinetic profiles and geometry that is evaluated with the MHD equilibrium code CHEASE [Lütjens1996]. Linear simulations show signatures of diverse range of electrostatic and electromagnetic modes, including the Ion Temperature Gradient (ITG) instability, Trapped Electron Modes (TEM) and microtearing modes. While many studies have been dedicated to understanding electrostatic turbulence, electromagnetic results in reactor relevant scenarios are few and many questions of finite β effects still remain unanswered. We address these questions in the present contribution by retaining all important physical effects in the gyrokinetic simulations. The large value of β implies that both perpendicular and parallel magnetic field fluctuations have to be retained, since they both play a role in the underlying instabilities, as illustrated by linear simulations in Fig. 1. While the effect of compressional magnetic field fluctuations is neglected in many gyrokinetic codes, it can be consistently included in GENE using full grad(B) and curvature drifts of the guiding centre orbits of the kinetic species[Waltz1999]. We consider four kinetic species in our simulations: electrons, main deuterium ions, carbon impurities and fast ions to model external NBH heating. Carbon is found to reduce the growth rate of both the TEM and the ITG modes while fast ions mostly reduce the growth rate of ITG modes. It is known that the effect of fast ions on ITG is further enhanced by perpendicular magnetic field fluctuations in non-linear simulations[Citrin2013]. We investigate in particular how the effect of the various species changes when we include also compressional magnetic field fluctuations.

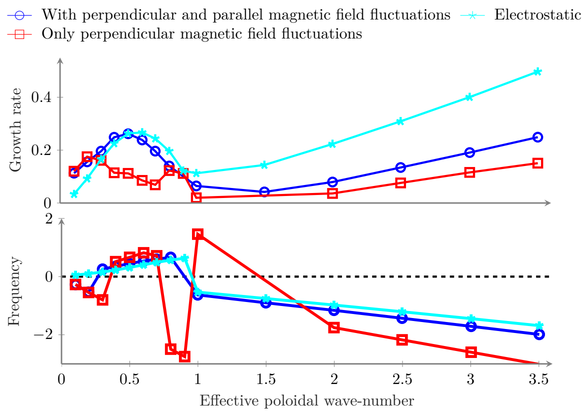

Figure 1

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