Contribution ID: **68** Type: **Poster**

Steady State Turbulent ITER-like Plasmas with RF drivers

Wednesday 19 October 2016 08:30 (4 hours)

First stability and transport in RF driven plasmas in ITER-like geometries are investigated using new kinetically modified MHD stability equations analyzed with theory and advanced simulations. Extended MHD stability analysis describes in detail the outer most closed flux surfaces inside the magnetic separatrix where ions and electrons dynamics differ. The new physics includes the effect of charge separation in response functions used in MHD-ballooning modes with contributions from the anisotropic pressure tensor from the different ion and electron dynamics in this steep pedestal gradient region. Different responses of trapped and passing electron orbits just inside the magnetic separatrix gives rise to the I-mode confinement. Nonlinear dynamics is shown to be Hamiltonian, by Morrison et al. New invariants are found that give rise to a new form of the energy principle and place constraints on turbulent cascades. Generalized helicities are associated with topological invariants. These invariants can be used to assess relaxed states akin to Taylor-relaxation. RF heating is investigated comparing results of mode conversion through upper-hybrid resonance layer where fast mode couples to the Bernstein slow waves. Fully kinetic particle-in-cell (PIC) simulations are performed with an open source code EPOCH. The code has been benchmarked at relatively low field amplitudes. Electron anisotropy in the ITG and ETG turbulence is analyzed with kinetic theory and used to describe the steady state response of the RF wave driven heating and current drive from RF waves in Tore Supra. Their extension to WEST plasmas is presented including the change in the heating across the magnetic separatrix. The turbulence in the electron density scatters direction and polarization of the current driving lower hybrid waves. The model is applied to experiments in Tore Supra and EAST and to the upcoming experiments in WEST. Scattering of the launched LHCD waves by the ETG turbulence gives the turbulent electron distribution functions. The RF wave scattering by the turbulence in the electron density is required to explain the broaden, anisotropic fast electron energy spectra measured deduced from the X-ray spectra in Tore Supra and EAST tokamak experiments. [W. Horton,M. Goniche,Y. Peysson, et al., PoP 20, 112508 (2013)and J. Decker, Y. Peysson et al. Physics of Plasmas 21, 092504 (2014)].

Paper Number

TH/P3-30

Country or International Organization

United States of America

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Session Classification: Poster 3

Track Classification: THC - Magnetic Confinement Theory and Modelling: Confinement