Coupled GEM-XGC Simulations of Edge Pedestal Plasmas

Y. Chen and S. E. Parker
Univ. of Colorado at Boulder
S. Ku, G. Y. Park and C-S Chang
New York University

In previous GEM flux-tube simulations of TEM turbulence it is found that when the density gradient is large, $R/L_n > 10$, the instabilities grow to large amplitudes without saturating. Since a density gradient of $R/L_n > 10$ is typical of edge plasmas, the stabilizing mechanism for such plasmas is of interest. We carried out gyrokinetic simulations of such plasmas by coupling the gyrokinetic turbulence code GEM with the XGC edge code. The plasma profiles used in GEM are output from an XGC simulation of a DIII-D plasma. XGC's magnetic geometry includes the separatrix and the magnetic X-point. Only the plasma profiles inside the separatrix are output to GEM. Fluctuations are then assumed to vanish at the inner and outer radial boundaries.

Simulations indicate that the instabilities spectrum consists of a high-n component, with growth rates increasing with n, and a low-n (~ 10) peak. The growth rates of the high-n instabilities are reduced by finite-β (i.e., when magnetic perturbations are included), and are identified as electron drift waves. These modes do not cause large transport due to their smaller wavelengths. Anomalous transport is mostly caused by the low-n instabilities, which are mainly driven by the electrons, and are greatly enhanced by electromagnetic effects. This enhancement is not due to the destabilization of a different branch of modes such as the Kinetic Ballooning Modes (KBM) that become unstable at large beta in core plasmas, as the mode real frequency does not display a jump as would be expected from a transition to KBM. An equilibrium $\mathbf{E} \times \mathbf{B}$ flow is esential for the saturation of these modes. Without the $\mathbf{E} \times \mathbf{B}$ flow the modes continue to grow to very large amplitudes, eventually violating the gyrokinetic ordering. Even with the $\mathbf{E} \times \mathbf{B}$ flow, significant relaxation of the pressure profile occurs in the long term. In order to accurately estimate the transport coefficients from the simulations it is necessary to prevent such profile relaxation. Possible techniques will be discussed.