Experimental evidence for density-gradient-driven trapped-electron mode in improved confinement RFP plasmas

J.R. Duff[1], E. Parke[2], W.X. Ding[2], D.L. Brower[2], B.E. Chapman[1], J.S. Sarff[1], Z.R. Williams[1], M.J. Pueschel[1] P.W. Terry[1], D.J. Den Hartog[1], L.A. Morton[1]

1) University of Wisconsin-Madison

2) University of California Los Angeles

Density fluctuations in the large-density-gradient region of improved confinement MST RFP plasmas exhibit multiple features that are characteristic of the trapped-electron-mode (TEM), strong evidence that drift wave turbulence emerges in RFP plasmas when magnetic transport associated with MHD unstable global tearing modes are reduced. This talk will feature both experimental and gyrokinetic-modeling results, the latter revealing differences with respect to tokamak plasmas, such as a larger critical gradient. This work contributes to validation of key models and gyrokinetic codes important for all configurations. RFP core transport is normally governed by magnetic stochasticity stemming from multiple long wavelength tearing modes that arise from current profile peaking. Using inductive control, these tearing modes are reduced and global confinement is increased to that expected for comparable tokamak plasma. The improved confinement is associated with substantial increases in the thermal gradients, and we present evidence for the onset of drift wave instability. Density fluctuations are measured with a multi-chord interferometer with ~8 cm chord spacing. These fluctuations have frequencies > 50 kHz, and wavenumbers $k_{\varphi}\rho_s \leq 0.14$, which are clearly distinct from those related to global tearing modes. Their amplitude increases with the local density gradient and they exhibit a density-gradient threshold at $R/L_n \sim 15$, higher than in tokamak plasmas by ~ R/a. Gyrokinetic analysis (GENE code) provides supporting evidence for the appearance of microinstability in these plasmas. For the plasma conditions described here, the density-gradient-driven TEM is the dominant instability at the relevant radial locations. The experimental threshold gradient is close to the predicted critical gradient for linear stability. While nonlinear analysis shows a large Dimits shift associated with predicted strong zonal flows, the inclusion of residual magnetic fluctuations cause the collapse of the zonal flows and an increase in the predicted transport to a level close to the experimentally measured heat flux. Hence the impact of residual MHD instability is very important. Similar circumstances could occur in the edge region of tokamak plasmas when resonant magnetic perturbations are applied for the control of ELMs. Supported by USDOE.