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Excitation of Electron Temperature Gradient (ETG) Turbulence and Effect on Plasma Transport in LVPD

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Understanding electron transport across magnetic field lines in a fusion device is critical. Linear calculations based on numerical and theoretical models reveal that the ETG mode, which is responsible for the turbulence, is a fast growing instability driven by ∇T_e with growth rate $\gamma_{ETG} \approx \omega_{*T_e} = k_y \rho_e (c_e/L_{T_e})$, when $\eta_e = L_n/L_T$ exceeds a threshold value. Here c_e is the electron thermal velocity and L_n, L_{Te} are the density and temperature gradient scale lengths, respectively[1,2]. ETG is a short wavelength,$k_\perp \rho_e \leq 1 << k_\perp \rho_i$, and low frequency mode, ω in the range $\Omega_i < \omega << \Omega_e$, where $k_\perp$ is the perpendicular wave vector, ρ_r/Ω_e and ρ_i/Ω_i are the Larmor radii/ gyro frequencies of electrons and ions. Electron gyroscale fluctuations have been reported in National Spherical Torus Experiment[3] and their role have been invoked to explain the plasma transport in Tore Supra[4]. However, all signatures of ETG turbulence could not be obtained due to extremely small wavelength, $\rho_e \sim \mu m$ in the range of $k_\perp \rho_e \sim 1$, in high magnetic fields ($\sim 20kG$) of tokamaks. Further, tokamaks have complex geometries, which restrict measurement and have limited control over the parameters that govern the turbulence. Basic plasma devices (linear or toroidal), on the other hand, provide a simplified geometry and control of magnetic field, thus brings scale length of turbulence well within the measurable limits. This provide a clear incentive to study ETG in basic plasma devices such as Large Volume Plasma Device(LVPD). However, these devices usually have plasma, which is contaminated by the presence of ionising, hot and non-thermal electrons, a potential sources of instabilities. This renders making a case for ETG difficult.

An unambigous observation on electron temperature gradient (ETG) driven turbulence is reported in LVPD. In the Electron Energy Filter(EEF) modified dressed plasma, the observed ETG turbulence in lower hybrid range of frequencies $f = (1 - 80kH_z)$ is characterized by a broadband with a power law. The mean wave number, $k_\perp \rho_e = (0.1 - 0.2)$ satisfies the condition $k_\perp \rho_e \leq 1$ [5].

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