Density peaking by parallel flow shear driven instability

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Advances in basic plasma science have been significant over the past 10 years. In particular, basic experiments have contributed to the progress of plasma turbulence research through detailed fluctuation study. Examples include, but not limited to, detailed investigation of non-linear mode coupling of plasma turbulence,[1] non-Gaussian properties of turbulence driven particle flux and Reynolds stress,[2] etc. More recently, coupled dynamics of turbulence, density profile, and parallel flow structure has been reported from probe measurement in PANTA.[3] In that study, inward particle flux and density peaking was identified, with the simultaneous measurement of parallel flow structure and down gradient flux of the parallel momentum. Based on observation, it was speculated that parallel flow shear driven instability would be responsible for observed peaking behavior.

In this work, we discuss a possible origin of particle pinch observed in PANTA, based on a simplified model that extends Hasegawa-Wakatani model to implement parallel flow coupling. The model can capture both collisional drift wave instability and Kelvin-Helmholtz (KH) instability driven by ∇v_z (so-called D'Angelo mode[4]). Here we note that a similar model has been developed to study parallel flow shear effect on drift-ITG mode in sheared magnetic field.[5] The simplified model is used to calculate growth rate and show that ∇v_z driven KH instability becomes dominant when $\omega_{*e}^2 \ll 4(1+k_\perp^2\rho_s^2)(k_\| c_s \rho_s k_\theta \langle v_z\rangle' - k_\|^2 c_s^2)$. This is analogous to that for D'Angelo mode and more importantly, the condition can be satisfied for a set of plasma parameters for which density peaking is observed in PANTA. Fluctuation dynamics is formulated by calculating the evolution of fluctuation intensity. Quasilinear turbulence production rate is calculated and *it is shown that particle flux is inward when KH instability occurs.*

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