Instabilities, transport and structures in partially magnetized plasmas supported by the ExB current

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Partially magnetized plasmas supported by ExB electron drift are widely used in various devices for electric propulsion and material processing (Hall thrusters, magnetrons, etc… ) and also occur in the Earth ionosphere. Such plasmas are in strongly non-equilibrium states due to presence of the ExB electron current, plasma and magnetic field inhomogeneities, and various dissipative processes. As a result, these plasmas exhibit multitude fluctuations and coherent structures across wide range of frequencies and length scales. Despite long history of experimental and theoretical studies, nature of these fluctuations and anomalous transport is still poorly understood. An overview of theoretical model(s) and experimental results for fluctuations and instabilities in partially magnetized plasma discharge supported by the ExB electron current will be presented. The model describes several fundamental modes of partially magnetized plasma: ion sound mode, lower-hybrid mode and anti-drift mode due to plasma density gradient. Density and magnetic field gradients and the electron current result in complex coupling of various modes destabilized by the interplay of ExB drift, ion beam velocity, density and magnetic field gradients, collisions and ionization. The nonlinear simulations have been performed to investigate the nonlinear saturation of the instabilities and resulting nonlinear transport. The simulations demonstrate highly intermittent electron current with magnitudes generally consistent with typical experimental parameters. It is shown that while the most unstable are small scale modes, the dominant contribution to the anomalous transport is provided by the large scale modes. The nonlinear energy transfer to large scale modes is demonstrated in nonlinear simulations. Effects of the parallel electron dynamics and sheath boundary conditions is studied. The role of related electron cyclotron instabilities detected in PIC simulations will also discussed.