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Zonal Flow Associated with Electron Temperature Gradient Driven Drift Mode in a Linear Magnetized Plasma

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Zonal flows (ZFs) are low frequency secondary modes that causes density and potential fluctuations, and are theoretically known to regulate transport in magnetized plasmas (Lin et al. 2009). According to theory, primary modes like density and electron temperature gradient driven drift instability are thought to drive ZFs (Diamond et al. 2005). Experimentally, ZFs have been associated with density gradient driven drift mode (Fuzisawa 2009). Here, we have experimentally correlated the ZF with electron temperature gradient (ETG) driven drift mode in IMPED, a cylindrical linear magnetized plasma device (Bose et. al. 2015a and b). Low frequency fluctuations ($0.2-0.3\ kHz$) are identified as zonal flow by measuring radial (k_r), poloidal (k_θ) and axial ($k_\parallel$) wave number. It is found that k_θ and $k_\parallel$ are approximately zero while k_r is finite and its polarity reverses radially indicating that the mode is poloidally and axially symmetric with finite radial propagation. Amplitude of potential fluctuations are much higher than density fluctuations in agreement with theoretically predicted properties of zonal flow. Amplitude of zonal flow is found to be maximum at the location of minimum of electron temperature gradient (ETG) scale length (L_{Te}) and as the location of minimum of L_{Te} is changed, zonal flow is found to follow it. The radial variation of electron temperature, T_e and density, n are found to satisfy the criteria for the excitation of ETG driven drift mode viz, $L_{Te}/L_n<1.5$. Measurement of electron density fluctuations revealed a broadband spectrum at a frequency just above 300 kHz which is in close agreement with theoretically calculated frequency of ETG driven drift mode. Bicoherence analysis shows that zonal flow interacts with this broadband mode. Further, on reducing the collision frequency, we observed an increase in the amplitude of fluctuations due to zonal flow. According to theory ETG driven drift is a reactive mode which becomes stronger when collision frequency decreases. This further proves that the zonal flow is being driven by ETG driven drift mode.

References

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