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Measurements of Ion Density Fluctuations in Phase-Space[1]

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Resolving the ion density fluctuations in phase-space is a natural extension of the large number of density fluctuation measurements performed using electric probes, and opens a new window into the kinetic nature of density fluctuations in magnetized plasma. Using Laser Induced Fluorescence (LIF) and a two-point correlation function implementation, we resolve ion density fluctuations in space, time, and ion velocity. By computing the cross-power spectra between two spatially resolved LIF signals, the ion density fluctuations reveal two components with distinct correlation lengths. The largest component has a three-meter wavelength and is explained by fluid theory. In addition, a short wavelength component, with a short correlation length that is consistent with the ion mean free path, is detected. This latter component propagates at a phase velocity close to the ion parallel velocities. We refer to this newly-identified ion velocity-dependent component as the "kinetic component," which is associated with a spectral feature near ω^* characterized by $\delta\omega/\omega \sim 0.1$. As the ion-neutral collision frequency is increased in the discharge, we observe a threshold that is marked by a narrowing of the drift wave spectrum. At this threshold, the kinetic component vanishes. Through correlations between Langmuir probe and LIF, we measure the phase shift between the fluctuating potential and each velocity stream. We observe a velocity dependent fluctuation induced transport rate near the drift frequency, which significantly depart from the classical prediction of the drift wave transport rate. The basic issues in resolving the ion density fluctuations in phase-space, as well as the key physics components that we observe will be presented.

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