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Plasmas of arbitrary neutrality[1]

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The physics of partially neutralized plasmas is largely unexplored, partly because of the difficulty of confining such plasmas. Plasmas are confined in a stellarator without the need for a plasma current, and regardless of the degree of neutralization. The Columbia Non-neutral Torus (CNT) is a stellarator dedicated to the study of non-neutral plasmas, and partially neutralized plasmas. CNT is currently conducting the first systematic studies of plasmas of arbitrary neutrality. The degree of neutralization of the plasma can be parameterized through the quantity $\eta \equiv (n_e - Zn_i)/(n_e + Zn_i)$. In CNT, η can be varied continuously from pure electron ($\eta = 1$) to quasi-neutral ($\eta \approx 0$) by adjusting the neutral pressure in the chamber, which controls the volumetric ionization rate. Pure electron plasmas are in macroscopically stable equilibria, and have strong self electric potentials dictated by the emitter filament bias voltage on the magnetic axis. As η decreases, the plasma potential decouples from the emitter, and fluctuations begin to appear. For $\eta \approx 0.5$, the plasma oscillates at a single dominant mode (40 - 130 kHz) related to the $\mathbf{E} \times \mathbf{B}$ rotation of the plasma [1]. For $\eta \approx 0.01$, the plasma exhibits multiple mode oscillations. And when the plasma becomes quasi-neutral ($\eta < 10^{-4}$), it reverts to single mode behavior (2 - 18 kHz). The spatial structure of these low frequency oscillations in the quasi-neutral regime has been studied using a high speed camera, showing that the detected mode travels approximately perpendicularly to the field, but it is not perfectly aligned with the field lines. A parametric characterization of the modes detected in plasmas of arbitrary neutrality will be presented along with measurements of the spatial structure of the oscillations, with an aim to characterize the physics of the modes observed.

[1] Q. Marksteiner, PRL 100 (2008) 065002

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