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Ion-driven electron cloud dynamics in a non-axisymmetric torus: A 3D3V Particle-in-Cell study

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Recently, a quiescent quasi-steady (QQS) [1] of pure electron plasma confined using a toroidal magnetic field, in a tight aspect ratio, axisymmetric toroidal device, has been numerically discovered using a 3D3V particle-in-cell code PEC3PIC [1, 2]. The effect of ions on this quasi-steady equilibrium state has been reported [3]. Ions are introduced in the device in two ways viz. (i) ion cloud is preloaded along with the electron cloud at QQS state at certain pre-determined time [3] and (ii) ions are generated in the device via impact ionization using Monte-Carlo Collisional (MCC) method [4]. In both cases, as the ion fraction in the device increases beyond certain value, the electron cloud is found to be destabilized resulting in a finite amplitude m = 1 toroidal diocotron mode.

A quiescent quasi-steady state of pure electron plasma in experimental-like non-axisymmetric toroidal device with negative potential grids, has been achieved recently [5] using the non-axisymmetric version of the PEC3PIC [2] code. In the present study, the effect of ions on the quasi-steady equilibrium state of the electron cloud has been investigated. In contrast to the axisymmetric device, it has been demonstrated that the QQS state of the electron cloud dynamics is not affected (Fig. 1) by presence of ion population (Ar^+) (Fig. 2), for both the preloaded case and the MCC case.

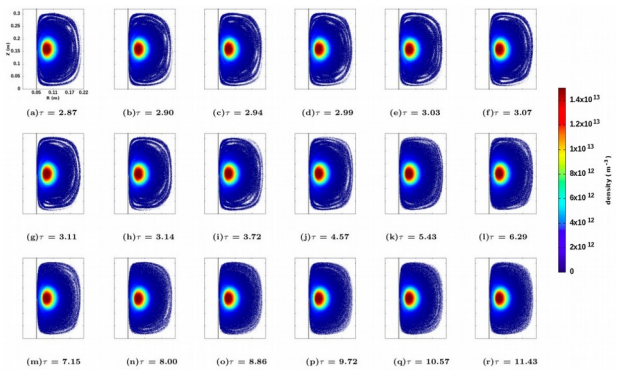

Fig 1. Evolution of electron density for QQS case in the poloidal plane for f (i.e. n_i/n_e) = 0.001 (preloaded case).

To verify if the results are unique to the QQS case, the MCC technique has been applied for the already destabilized electron cloud exhibiting m = 1 toroidal diocotron mode. For this case, the amplitude of m = 1 toroidal diocotron mode increases at initial time and later saturates. Details and probable physics reasons of such behaviors will be explained in the presentation.

References

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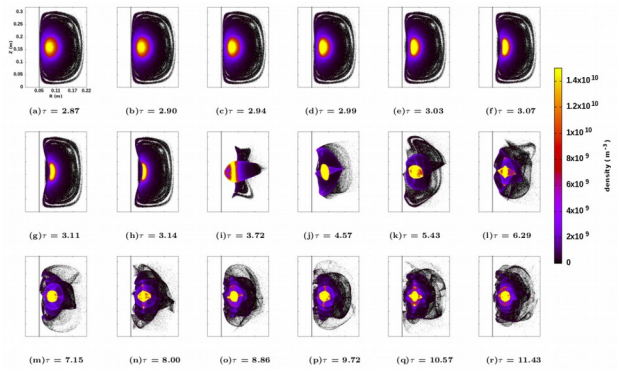

Fig 2. Evolution of ion density (Ar^+) for QQS case in the poloidal plane for f = 0.001 (preloaded case).