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Rotation-induced electrostatic-potentials and density asymmetries in NSTX

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The computation of rotation-induced electrostatic potentials is currently being used to study the associated two-dimensional distribution of impurity density asymmetries in NSTX and NSTX-U plasmas. The main effect of toroidal rotation on heavy impurities is their radial displacement to the outer plasma, which result in a non-uniform distribution around a magnetic flux-surface. Due to the different effect of centrifugal forces on electrons, main ions and low- to high-Z impurity density, an electrostatic potential is generated to satisfy quasi-neutrality. This calculation relies on flux-surface quantities like electron and ion temperature $(T_{e,i})$ and rotation frequency (ω_ϕ) and finds the 2D electron, deuterium and carbon density profiles self-consistently assuming the presence of a poloidal variation due to centrifugal forces. The few assumptions considered include a zero electron mass, a deuterium plasma, a trace impurity with charge "Z"given by coronal equilibrium and equilibrated ion temperatures (e.g. $T_D = T_C = T_Z$). The iterative solution for the electrostatic potential from the measured carbon density and central toroidal rotation using NSTX data are routinely obtained and compared with the values derived using the ideal formalism which assumes that the main low-Z intrinsic impurity (e.g. Carbon) is in the trace limit $\alpha_C \equiv 36 n_C/n_e \ll 1$; realistic values of the low-Z impurity strength factor can exceed one. While the carbon asymmetry is nearly three times stronger than the ideal description, the depth of the potential well in the high field side can reach -110 to -280 V for core rotation between 180 –360 km/s. This computation is being used to increase our understanding of medium- and high-Z asymmetries and the reduction of Z-peaking, to examine the effect of electrostatic potentials possibly changing the heat and particle transport, the reduction of the underlying turbulence due to $E \times B$, radiation asymmetries before tearing mode onsets, as well as to aid the design of new diagnostics for NSTX-U (e.g. ME-SXR, XICS, Bolometers, etc). The presence of O, Ne, Ar, Fe, Mo and W are considered at the trace limit with very small changes to quasineutrality and Z_{eff}. This work is supported by the U.S. Department of Energy, Office of Fusion Energy Sciences under contract number DE-AC02-09CH11466.

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