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. This calculation relies on flux-surface quantities like electron and ion temperature ($T_{e,i}$) and rotation frequency ($\omega_\varphi$) and finds the 2D electron, deuterium and carbon density profiles self-consistently assuming the presence of a poloidal variation due to centrifugal forces. The iterative solution \cite{1} for the electrostatic potential difference ($\Delta \phi = \phi(\theta) - \phi(\theta = 0)$) are routinely obtained and compared with the values derived from the ideal solution to quasi-neutrality, which assumes that the main low-Z intrinsic impurity (e.g. carbon) is in the trace limit. An \textit{ad-hoc} solution, which attempts to extend the ideal approximation beyond the trace limit \cite{2}, does not adequately captures the physics of finite mass and $Z_{\text{eff}}$. Nevertheless, the net-change of the plasma potential profile due to the presence of the rotation-induced electrostatic well is smaller than 6%. This calculation also finds 2D asymmetries for medium- to high-Z impurity density profiles that are at the trace limit with very small changes to quasi-neutrality and $Z_{\text{eff}}$. While the asymmetry in the core radiated power density from low-Z ions (e.g. D, C, O, Ne) is relatively small, the core density and radiation from medium- to high-Z’s (e.g. Ar, Fe, Mo, W) will be strongly affected by centrifugal forces. This work is supported by the U.S. Department of Energy, Office of Fusion Energy Sciences under contract number DE-AC02-09CH11466.

\cite{1} E. Belli and J. Candy, PPCF, 51, 075018, (2009).
\cite{2} T. Odstrcil, et al., PPCF, 60, 014003, (2018).