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NBI and HHFW Fast Ion Temporal Dynamics Modeling with CQL3D-Hybrid-FOW in NSTX Discharges

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The CQL3D Fokker-Planck code[1] has been upgraded to include physics of finite-orbit-width (FOW) guiding-center orbits[2,3], as compared with the previous zero-orbit-width (ZOW) model, and a recent first-order orbit calculation[2]. The Fast Ion Diagnostic FIDA[4,5] signal resulting from neutral beam (NBI) and high harmonic fast wave (HHFW) RF power injected into the NSTX spherical tokamak can now be modeled quite accurately using ion distributions from the CQL3D-Hybrid-FOW code, a rapidly executing variant that includes FOW+gyro-orbit losses to the plasma edge, FOW effects on NBI injection and HHFW diffusion, but does not include neoclassical radial diffusion. Accurate, prompt FI losses are a key feature of the marked modeling improvement relative to previous ZOW results. By comparing NBI-only and NBI+HHFW shots, independent confirmation of the usual 35% edge loss of HHFW in NSTX is obtained. Further, HHFW prompt losses from the plasma core are shown to be 3X as large (>25% total) as the NBI-only case. Limited neoclassical radial diffusion calculations show an increase of the FI distribution at large plasma radius, consistent with the near edge signal from the FIDA[5]. The modulated NBI and time-dependent background plasma variations are accounted for, also giving temporal neutron variation in approximate agreement with NSTX observations.

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[1] R.W. Harvey and M. McCoy, "The CQL3D Fokker Planck Code,"http://www.compxco.com/cql3d.html.
[2] R.W. Harvey, Yu. Petrov, E.F. Jaeger, W.W. Heidbrink, G. Taylor, C.K. Phillips, B.P. LeBlanc, "First order finite-orbit-width corrections in CQL3D Ion Fokker-Planck Modeling of the NSTX HHFW Experiment", EPS, Strasbourg, France (2011).
[3] Yu. Petrov and R.W. Harvey, "Finite Orbit Width Features of the CQL3D Code", Proc. of IAEA FEC, San Diego(2012).

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