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Pedestal-to-Wall 3D Fluid Transport Simulations on DIII-D and NSTX

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The 3D edge transport code EMC3-EIRENE is used to test magnetic field models with and without plasma response against experimental data on DIII-D and NSTX for a range of collisionalities, including the transition to detachment. None of the models tested can quantitatively reproduce the measured 'lobe'structure in the scrape off layer (SOL) temperature and density while maintaining the experimental pedestal pressure gradient. To make reliable predictions for future devices such as ITER, which will operate with applied and intrinsic 3D fields, transport simulations must be able to reproduce experimental observations in the edge, divertor, and pedestal. This "pedestal-to-wall"consistency depends strongly on the structure of the 3D magnetic field model in which EMC3-EIRENE solves the fluid plasma and neutral particle transport equations. The magnetic fields used include axisymmetric equilibria, a superposition of 2D and 3D vacuum perturbation fields, and 3D MHD codes which include plasma response (VMEC [2], GPEC [3], M3D-C1 [4]).

In DIII-D plasmas the divertor Thomson scattering system measures structure in the temperature and density that is not present in axisymmetric plasmas. These measurements are compared to EMC3-EIRENE simulations using vacuum and M3D-C1 fields. The two fluid M3D-C1 cases show lobes that are significantly larger than experimentally observed. These comparisons will be used to constrain inputs to the simulations such as the edge rotation profile that have large experimental uncertainty. In NSTX, 3D field application is observed to cause detached plasmas to reattach. As the density is increased, heat flux peaks at large major radius remain even as the primary peak is reduced. EMC3-EIRENE simulations reproduced these trends, with axisymmetric cases transitioning to detachment at a lower density than when 3D fields are included and the heat flux peaks caused by strike point splitting transitioning to detachment from the primary strike point outwards as the density is increased.

[1] Y. Feng, et al., J. Nucl. Mater., 241-243, 930 (1997)
[2] S.P. Hirshman, et al., Phys. Fluids 26, 3353 (1983)
[3] J.-K. Park, et al., Phys. Plasmas 14 052110 (2007)
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