Validating predictive models for fast ion profile relaxation in burning plasmas

N. N. Gorelenkov\textsuperscript{1}, W.W. Heidbrink\textsuperscript{2}, G. J. Kramer\textsuperscript{1}, J. Lestz\textsuperscript{1}, M. Podesta\textsuperscript{1}, M.A. Van Zeeland\textsuperscript{3}, R. B. White\textsuperscript{1}

\textsuperscript{1}Princeton Plasma Physics Laboratory, Princeton University; \textsuperscript{2}University of California, Irvine, \textsuperscript{3}General Atomics, San Diego, California

The redistribution and potential loss of energetic particles due to MHD modes can limit the performance of fusion plasmas by reducing the plasma heating rate. In this work, we present validation studies of a 1.5D or Critical Gradient Model (CGM) for Alfvén eigenmode induced EP transport in NSTX and DIII-D beam heated plasmas. In previous comparisons with a single DIII-D L-mode case, the CGM model was found to be in surprisingly good agreement with measured AE induced neutron deficits [1]. Application to DIII-D advanced tokamak plasmas however, showed the need to expand the linear stability analysis to nonperturbative regimes [2]. With the use of the fully kinetic nonperturbative code HINST it is found that AEs show strong instability drive, $\gamma/\omega \sim 20 – 30\%$, violating NOVA-K perturbative assumptions. In the CGM, it is assumed that all fast ions are affected, even when they are not in resonance with the underlying eigenmodes. This situation is natural for a plasma with strong collisions or strong AE overlapping. As shown in Fig. 1 (left) both models agree with each other and both underestimate the neutron deficit measured in the DIII-D shot.

On the other hand in NSTX the application of CGM shows agreement with the measured flux deficit as shown in Fig. 1 (right). We discuss possible explanations of these DIII-D discrepancies between the measurements and CGM predictions. We also attempt to understand these results with the help of the guiding center code ORBIT. The ORBIT comparison allows insight into the underlying velocity space dependence of the AE induced EP transport.


Figure 1. Neutron flux deficit computed with the help of CGM is compared with the measured deficit in DIII-D shot #153072 as shown in left figure. Shown on the right is the perturbative CGM application for NSTX plasma.