Critical Gradient Model for Fast Ion Profile Relaxation in Tokamaks

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Objectives

- Predict fast ion profiles for successful operation of future fusion devices, such as ITER
- Develop analytical model of Alfvenic instabilities that are responsible for fast ion profiles evolution
- Challenges of this study:
  - Requires self-consistent analysis of multiple Alfvenic instabilities saturation and their effect on fast ion profiles.

Accomplishments

- The analytical model is developed that can predict fast ion pressure profiles. The model determines the critical gradient of the fast ion pressure. It is shown that the instabilities lead to profiles with the pressure gradient not exceeding the critical value of the gradient above which instability develops.
  [K. Ghantous, et al., Phys. Plasmas 19, 092511 (2012).]
- The developed model explains the experimental fact that the observed profiles of fast ions in DIII-D weakly depend on the injection geometry as shown in Fig.2.

Impact

- Fast ion profiles are critically important for ITER, because they determine the loss level of fusion alpha particles and, correspondingly, determine the safe regions of plasma operations.

Fig.1 shows expected losses of alphas in ITER due to Alfvénic instabilities excited in H-mode plasma as well as the regions of potentially strong and benign alpha losses.

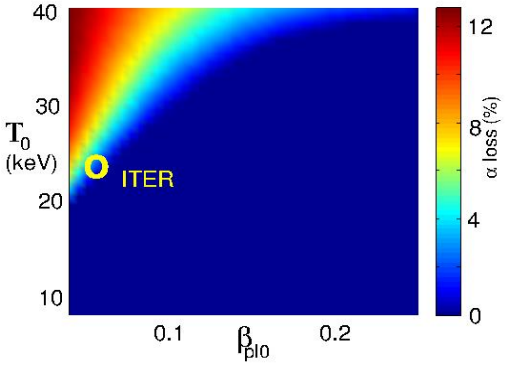
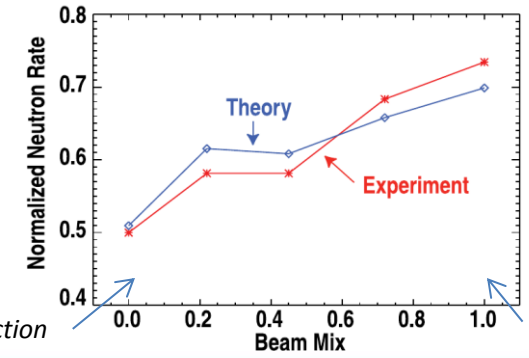


Fig.2 Comparison of theoretical predictions using NOVA-K instability calculations and DIII-D experimental data
[W. Heidbrink, et al., Nucl. Fusion 53, 093006 (2013).]



2 beam core injection

1 beam edge + 1 beam core injection

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