CHI Scenario Studies on NSTX and Modeling Support

Xianzhu Tang
Plasma Theory Group, Theoretical Division
Los Alamos National Laboratory

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Gauge the success of CHI for startup?

- High toroidal/injector current ratio (> 10 multiplication factor).
  A measure of average q.

- 2D resistive MHD simulation shows a tendency of edge localization of plasma current.

- High plasma current is useful if the corresponding poloidal flux can be reused by a secondary current drive scheme.

- 3D instability may be used to redistribute the plasma current and produce usable poloidal flux.

- Field line topology can be inferred from transport, if 2D measurement exists (NOT currently available).

- Comparative experiments could overcome the constraint of 1D transport measurement.

MHD Scenario for CHI

- Low ψ_i and high V : 2D tearing dominates. Ejects a stream of plasmoid, with vertical PF control, they coalesce to form a single null region. Otherwise, they reach absorber and ignite arching.

- Moderate ψ_i and V : Magnetic tension is strong to hold the magnetic expansion in check. Minimum 2D tearing, usually in the very center of the magnetic bubble. 3D instability is weak if exists at all.

- Moderate ψ_i and high V : Strong localized plasma current at the edge of the injector flux. Drives strong $n = 1$ line-tied kink. The poloidal mode number is inversely proportional to V. Significant plasma current redistribution due to 3D modes.

- High ψ_i : Essentially gears toward a low average q configuration. Multiplication factor is small.

Calibrating transport in 2D MHD regime

- A series of low V CHI shots, coupled with localized plasma heating, can benchmark the 2D MHD modeling effort. The ideal is to use transport to infer changes in magnetic topology

- With a constant V, 2D resistive steady state can be setup with open field lines. When the voltage is modulated (on resistive or half-power of the resistive time scale), 2D magnetic reconnection is induced and large central closed flux can form.

- If the center of the plasma is locally heated, the mid-plane temperature measurement should also modulate following the voltage. The absolute value can be compared with the constant V and hence open field configuration.

- The goal is to establish a flux handover scheme for secondary current drive in the 2D MHD regime.

Possible gain in 3D MHD regime

- 2D MHD regime can have high plasma/injector current ratio, but the center closed flux region has little rotational transform.

- 3D MHD regime offers the potential for significant current redistribution and hence profile control.

- Previous voltage modulation experiments can be repeated for high V shots. The ideal scenario is that as voltage drops, 3D modes decays faster and the $n = 0$ state provides good confinement with low q profile. This can be checked by transport and center q measurement. It should be noted that the q profile rather then the current multiplication factor is the one being optimized here.

- If it is successful, a much more useful magnetic configuration can be handed over to secondary current drive.

Theory and Modeling Support

- We plan to support these experimental scenario studies for plasma startup on NSTX with theory and numerical modeling effort.

- The voltage mudulation in the 2D MHD regime has been calculated and its implication on magnetic topology is the basis for suggesting these experiments. The transport measurement can benchmark and improve our modeling capability.

- 3D MHD startup scenario still requires a detailed calculation, which we plan to follow up in the near future.

- Hopefully, a combined experimental and modeling effort could lead to predictive CHI startup operation on NSTX in five years.