Discussion: Possible New Disruption Related Physics Problems for NIMROD

The evolution to disruption naturally divides into a set of four stages: Linear growth, Quasilinear and Nonlinear Growth, Possible Saturation leading to nonlinear evolution on longer transport timescales, and Disruption Events (-> Possible mitigation).

There is a renewed focus on understanding the latter two of these stages for programmatic reasons (ITER needs). Here we discuss a set of four physics areas where the NIMROD team is or can contribute:

- Wall forces, halo/Hiro current
- Physics of halo current width and its ability to stabilize the plasma column
- The interaction of a nonlinear rotating island (even small) with the wall during entry into the thermal quench.
- Runaway Electrons
- Other areas?

Discussion

Physics Goals: what are we trying to newly understand?

Analytic and Computational Modeling Needs: what is the current state, what is needed?

Experiment Comparison via Diagnostics: what are the measurements to compare to simulations?

Evolution to disruption event can be considered as set of four stages

Consider the stages of evolution to disruption caused by an MHD instability:

1. Linear growth
2. Quasilinear and nonlinear growth
3. Possible saturation leading to nonlinear evolution on longer transport timescales
4. Disruption events (-> Possible mitigation)

Different experimental configurations can have different important physics within each of these stages

- subtle task to compare simulation and experiment to isolate any single physical effect and test its theoretical description.

If the growth of the mode slows and confinement persists on longer timescales, the system can be considered to be in three dimensional equilibrium. As the system evolves the various drivers change, and the detailed physics of the mode evolution under this changing drive can determine if the system evolves to disruption or not.

Wall forces, halo/Hiro current

- Need finite radial velocity boundary condition in addition to resistive wall
  - Relevant when plasma is in contact with wall during disruption
  - plasma flows out to contact wall at sound speed and is lost
  - resistive wall provides E_t which can be used to get a V_n

- M3D (Josh) is planning a VDE study with the "right" boundary condition, to compare results with Leonid
  - We're (cordially) invited to contribute - timescale until possible?

- Cylindrical treatment has a banded wall contact, while toroidicity allows for a localized foot point
  - 3D structure not considered in current and ongoing analytic analysis
  - Not in cylinder without special boundary (for example flat)
  - Physics of the driven currents and heat loads changes substantially

- Consider sources: timescales of event vs source rate
  - With a V_n is this handled correctly in NIMROD

Physics of halo current width and its ability to stabilize the plasma column

- Currents prevent kink from growing Alfvenically, analogy to RWM
  - Thin halo current channel is unable to stabilize
  - induction/impedance problem
- Possible to study and specify the width of the halo current with a 3D resistive region and boundary conditions?
  - What determines the width of the Halo current?
  - The stability of a kinked plasma column with halo current coupled to conditions in wall and surrounding region

The interaction of a nonlinear rotating island (even small) with the wall during entry into the thermal quench

- What is the phsyical mechanism for the sudden loss of good surfaces and confinement leading to the sudden thermal quench?
  - Locking allows more flux to penetrate the wall, causing larger perturbations.
  - There is also a (related) penetration problem within the plasma.

- Which or what physics is responsible for the sudden thermal quench.
  - What is physics of sudden surface breakup?
  - Last closed surface vs. good surfaces
  - Also microturb transport changes to Bohm

- The thermal quench event leads into RE
  - What determines the size of the RE beam?
- After thermal quench do surfaces heal?

Runaway Electrons

- Difficult to implement a RE generation model?
- Have model for current generated (Rosenbluth, Putvinski, NF 97 eq 18)
  - Need model of electric field for REs, or assume no E?
  - $J\text{-}J_{RE}$ in usual Ohm's law
  - Boozer suggests two Ohm's laws, reasonable?

Possible ideas:

- When resonant surface inside RE beam, stability is not yet understood
  - Stability of surrounding plasma independent of RE collisionality
- Thermal quench to RE beam generation study : surfaces and confinement vs sourcing
- What determines the width of the current?
- The (possibly 3D) equilibrium state and stability of the RE's
- Need basic theory of crescent observations
  - what do the experimentalist know?
  - Is it pitch angle scattering?
  - Is there an observed 3D state?