APS Invite Preview – Buttery: *"Tearing Under Stress – The Collusion of 3D Fields and Resistivity in Low Torque H modes"*

- **Motivation:** *Understand error field thresholds and correction requirements in ITER H-mode – consider actual mode threshold, resistive response, mode formation*
- **Content:** ***DIII-D & NSTX data, MARS & M3D-C1 modeling, IPEC'd thresholds:***
  - D3/NSTX scans showing error threshold falls as TM limit approached in rotation & β
  - Comparison of n=1 (resonant) and n=3 (non-resonant) braking effects (NSTX)
  - Scalings of error field threshold vs main parameters in torque free and high rotation discharges → projection to ITER error field threshold in IPEC resonant boundary field
  - Identification of resistive response in plasma at low rotation (D3)
  - Modeling of plasma ideal+resistive response vs rotation, beta and current profile
  - Ongoing ITPA MHD studies on capabilities of single/multi-harmonic correction in ITER
- **Conclusions: New challenges identified for correction of error fields**
  - Low torque opens the door to resistive response to 3D field
  - 3D fields interact with natural tearing β limit through braking
  - Error correction in low torque H mode even more challenging than Ohmic regime
  - New scalings obtained to predict ITER correction requirements in H mode
  - Ongoing fascinating work to understand resistive response & error correction

Reserve information / Answers to Questions

- *Did this last year – JK Park gave excellent talk. What's new?*
  - Yes he did. But this proposal moves the topic on in two key ways:
    - It focuses on the resistive response, not considered in past talks
    - It looks not just at plasma response, but on actual limits from resistive modes, how they arise and how they scale – these depend on torque balance, underlying plasma stability, and many further things
- *We understand the plasma response already – lots of good progress on this with IPEC, Reimerdes, …*
  - While we understand plasma ideal response to 3D fields (which applies at high rotation, away from beta limits), actual mode thresholds – and so correction requirements depend on criteria to make a tearing mode. Here, by definition, resistive response plays a role, as does natural tearing stability and deltaprime.
- *This is a repeat of old Buttery and La Haye work on rotation dependence of NTMs*
  - Not true. The old work did not make reference to error fields – just looking at tearing stability vs rotation. While this is a part of the process here, the key thing is in understanding how a 3-D field couples to the plasma, induces braking and causes the mode.
- *This was already covered in Buttery's contributed 2010 APS.*
  - Partly true, we did cover some experimental results. But we did not discuss mechanisms of mode onset, continuity between locked and rotating data, NSTX results, or the many scans exploring various parameter dependencies with MARS. We also have further scans with M3D-C1 showing differences in modeled behavior now, which will tell us more about the important parts int eh underlying physics.
- *ITER has an error correction system – what's the problem?*
  - These results show correction requirements go beyond on original specification, and may become more demanding still for higher beta plasmas. They also show that different types of field (non-resonant and resonant) are important to consider.
- *ITER has gyrotrons too to get rid of modes.*
  - A good point. This work is crucial to understand the need and role of these gyrotrons (is continuous suppression needed), and how to operate them to improve stability (eg through current profile modification).