

Selected Summary of the Joint Meeting of the ITPA MHD Stability Topical Group and US-Japan workshop on “Physics of MHD Control of Toroidal Plasmas”

March 8-12, NIFS, Toki, Japan



Topics

To be covered

- NTM and Locked Modes
- Error Fields and 3D perturbations
- RWM stability analysis
- ELMs
- Disruptions

Not to be covered

- MHD experiments in Stellarators
- LHD theory and analysis
- RFP experiments and analysis

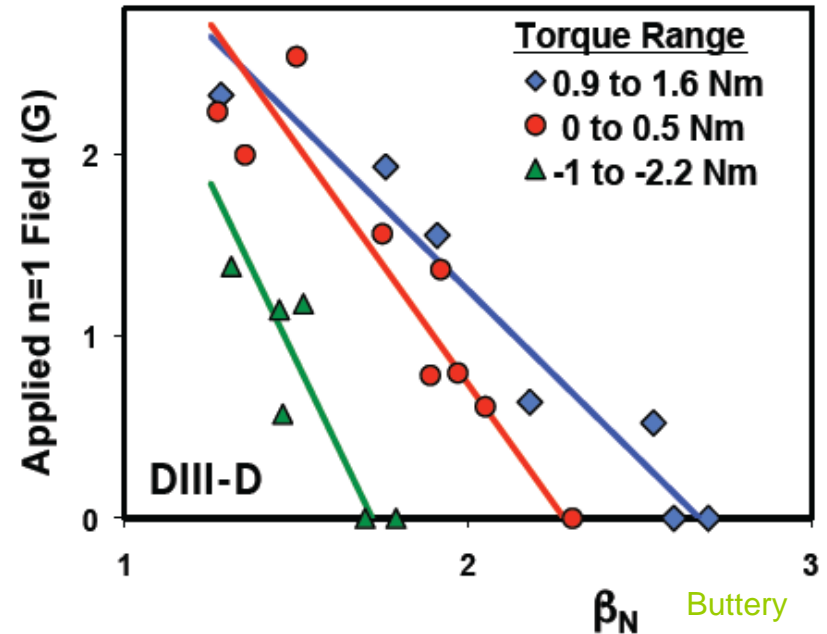
A Complete Meeting Agenda is posted on the CEMM WebSite w3.pppl.gov/CEMM. You can send me a request for any presentation.

NTM and Locked Modes

- DIII-D Locked Mode Experiments
 - If mode locks where ECCD cannot reach it, can cause disruption
 - Successfully unlocked a “locked mode” by rotating RMP, applied ECCD, and prevented a disruption
- Sauter – 1D modeling using ASTRA with Porcelli model of sawtooth
 - Reference sawtooth period of 40s can be varied 28-70s with ECCD
 - May be more efficient to control sawtooth than to stabilize NTM

Error Fields and 3D perturbations

- Tearing mode β_N limits fall at low rotation (and low rotation shear)
 - 3D (error fields) also lower tearing β_N limits – this is worse at low torque
 - Suggests 3D field response enhanced by proximity to tearing limits



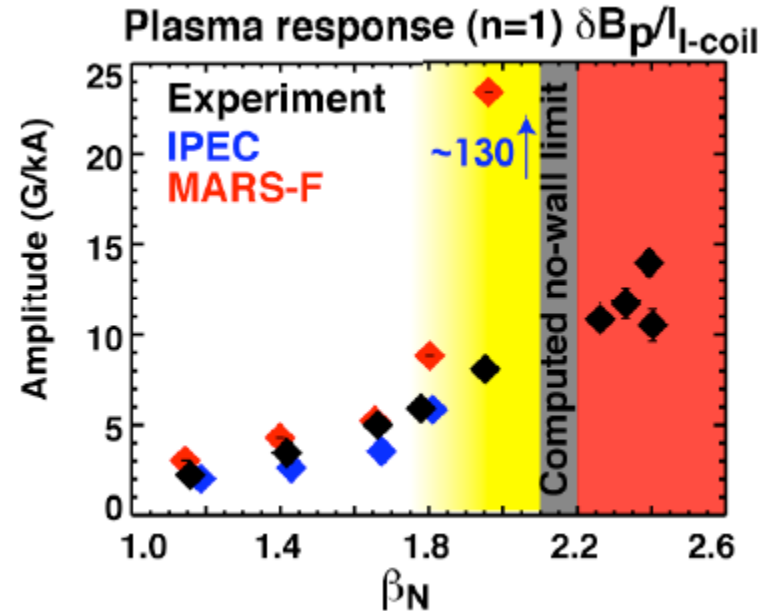
Above line, NTM appears.

RWM stability analysis

- Ideal MHD theory fails for $\beta_N > 80\%$ of no-wall stability limit (DIII-D)
- There is *some* experimental support for the perturbative formula that includes particle resonances through a kinetic component (Hu, Betti):

$$\gamma\tau_A = -\frac{\delta W_\infty + \delta W_K}{\delta W_a + \delta W_K}$$

- However, a self-consistent non-perturbative treatment is needed.
- Energetic Particle effects also important
- Statistical evidence on NSTX that RWM feedback is stabilizing



Ideal MHD fails at high β_N (Strait)

- Dynamic error field correction being used in both RWM stable and unstable regimes (Okabayashi)
 - total current from one shot used as pre-programmed for next

ELMs

- DIII-D ELM Pacing experiments:
 - Deuterium pellets at edge to trigger small rapid ELMs
 - Oscillating $n=3$ fields can pace ELMs up to 20 Hz
 - I-coil RMP fields can reproducibly suppress all ELMs
- NSTX ELM pacing experiments
 - Reliable triggering with pulsed 3D fields up to 30 Hz
 - ELM pacing with vertical jogs demonstrated
- Linear theoretical work (MINERVA code) by Aiba shows that sheared toroidal rotation can destabilize the peeling ballooning mode.

Disruptions

- Disruption mitigation experiments on DIII-D
 - Massive gas injection reduces heat loads and halo currents
 - Shattered pellets of cryogenic D_2 and Ne
 - Shell pellets filled with impurities (B, Ar)
 - De-confinement of runaway beams with applied $n=3$ perturbations
- Also performed experiments on DIII-D demonstrating that the (R,Z) position of the runaway electron beam can be controlled
- RMP ineffective in removing Runaway Electrons in JET disruptions
- Several efforts are underway to benchmark TSC and DINA code halo-current models with ASDEX-U and NSTX
- Sideway force on ITER vacuum vessel are predicted to be considerable.
 - Caused by toroidal asymmetry of vessel currents...assumed to be $\sim 10\% I_p$
 - Now primarily seen on JET...how to extrapolate to ITER?
 - Asymmetry may rotate or be static
 - 3D code to predict this is a high priority

ITER related Opportunities for CEMM

- **NTM and Locked Modes**
 - Clarify NTM seeding physics and scale to ITER parameters
 - Model mode-unlocking by rotating fields and scale to ITER parameters
 - Power requirements for NTM stabilization by ECCD
- **Error Fields and 3D perturbations**
 - Effect of 3D error fields in rotating plasma
 - Dependence of NTM threshold on proximity to tearing mode threshold
- **RWM Stability Analysis**
 - Include kinetic terms in a non-perturbative way
 - Scaling to ITER parameters
 - Nonlinear effects
- **ELMs**
 - Scaling of present results to ITER parameters: heat pulses, triggering, etc.
 - What is the origin of the criteria $\gamma > \omega^*/2$ used by Snyder
 - How does the current evolve in the stochastic fields?
 - What happens to the total plasma current and bootstrap current during the ELM?
- **Disruptions**
 - 3D modeling of the halo-current asymmetry and sideways force, benchmarking on NSTX and scaling to ITER
 - Runaway electron modeling and scaling to ITER