Some MHD highlights from the IAEA

13-18 October 2008

ITER demonstration discharges (DIII-D, JET):

	q_{95}	q_{min}	β_N
Baseline (scenario 2):	3.0	~1.0	2
Steady-state (scenario 4)	4.7,	~1.5	2.7-3.0
Hybrid (scenario 3):	4.1,	> 1	~ 2.8
Advanced inductive:	3.3,	> 1	~2.8

Demo of high β_N, high f_{BS} fraction discharges (toward steady state):

	β_N,	f_{BS}	q_{95}	q_{min}
JT-60U	2.7	90%	5.27	2.4
JET	2.8	50%		
DIII-D	2.7-3.0		4.7	1.5

Features of Hybrid Discharge (D-III)

- Suppressed sawteeth
- Higher β limit
- Better transport
- ELM suppression with RMP demonstrated on DIII-D for $q_{95} \sim 3.6$

Momentum Transport

- $\chi_{momentum} >> \chi_{heat}$ in NSTX , also momentum pinch from low-k turbulence
- $\chi_{momentum} \sim \chi_{heat}$ in JET : also large momentum pinch up to 20 m/s
- Evidence for “anomalous torque source” in DIII-D. Also, momentum pinch
- DIII-D finds for intrinsic rotation: $V_\phi \sim T_i$ at edge, consistent with ion orbit loss
- Plasma rotation in CMOD increases in counter-direction with LHCD power

Suppressing ELMs with RMPs

- ELMs suppressed on DIII-D for resonant windows q_{95} ~ 3.6 (and q_{95}~7.4)
  - Chirikov island overlap parameter also needs to be satisfied
- On JET, n=1 error fields can increase ELM frequency from 30 to 120 Hz
  - $\Delta W_{ELM}/W$ decreases from 7% to below 2% due to drop in particle flux

Theory

- Becoulet: reduced MHD: study of rotation effects on RMP penetration
- Strauss: MHD and 2F modeling of RMPs, rotation, ELMs

Suppressing ELMs with Pellets

- Pellets injected from the LFS observed to trigger ELMs on AUG, JET

Predictive model for pedestal height

- Empirical model: pedestal width $\Delta\Psi \sim (\beta_{P\text{-pedestal top}})^{1/2}$ on DIII-D, AUG, MAST
  - Pedestal height set by peeling-ballooning MHD constraining pressure gradient

Theory

- Aiba (JAERI): new linear MHD initial value code MINERVA: toroidal rotation can stabilize MHD modes in edge pedestal

Resistive Wall Modes

- NSTX operates above no-wall limit with rotation and active n=1 control coils
  - When rotation is suppressed, beta limit is reduced to no-wall limit
  - Recent experiments with $\beta > \beta_{NO\text{-}WALL}$ but rotation zero at q=2 surface
- JT-60 produced stable plasmas with β_N (2.8) > $\beta_{N\ no\text{-}wall}$ (2.4) with rotation
- DIII-D showed complex RWM behavior (Okabayashi)
  - Coupling to ELMs, non-rigid plasma response

Theory

- Liu (Culham): Looked at kinetic damping of the RWM with Perturbative and non-Perturbative (NP) MARS-F code. Concludes NP is essential

Ideal Perturbed Equilibium Code (IPEC)

- J.K. Park and A. Boozer have modified the DCON code to compute ideal perturbed equilibrium that gives plasma response to error fields
- Claim to have experimental verification on DIII-D and NSTX
  - Locked mode onset, RMP experiments

NTM Control

- NTM stabilization with ECCD demonstrated on JT-60U and HL-2A (and DIII)

Disruptions

- Improved halo current measurements in JET
  - Does not observe TPF > 2
- Improved characterization of current decay time in JET
  - L/R time with changing L
- Fast Plasma Shutdowns with Massive gas injection on DIII-D and AUG
  - With sufficient injected gas quantity, effective disruption mitigation is obtained

Sawtooth---theory

- Chapman: effects of fast ions, toroidal rotation, and magnetic shear
  - Explains shorter sawtooth periods in JET, MAST, and TEXTOR

ITPA meeting on MHD Stability

Oct 20-22, 2008

- Vertical Stabilization
- Disruptions
  - Further improvements in the halo current modeling are needed to decrease the uncertainty and to improve the estimates for both mechanical and EM loads
  - Detailed modeling of runaway formation during disruptions is needed
- NTMs
  - Data from (DIII-D, JET, NSTX, JT-60U) show clear evidence of the effect of plasma rotation (magnitude and sign) on the threshold β_N for onset of NTM. Need better theoretical models for this
- RWM control
  - JT-60 reports an energetic particle excited wall mode (EWM)
  - DIII-D reports a fishbone driven RWM
  - Several linear RWM codes being validated: VALEN, STARWALL, CARMA … need for nonlinear extended MHD code?
- Error Field Control
  - Error field requirements for ITER are still an open issue
- ITER Magnetics Diagnostics
- Joint Experiments
  - MHD modeling of these would be useful