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# $38^{th}$ EPS Meeting (2011) – Some Comments on Stability and other Presentations


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# Balance of Monday AM plenary talks covered first wall/ materials, and space plasmas

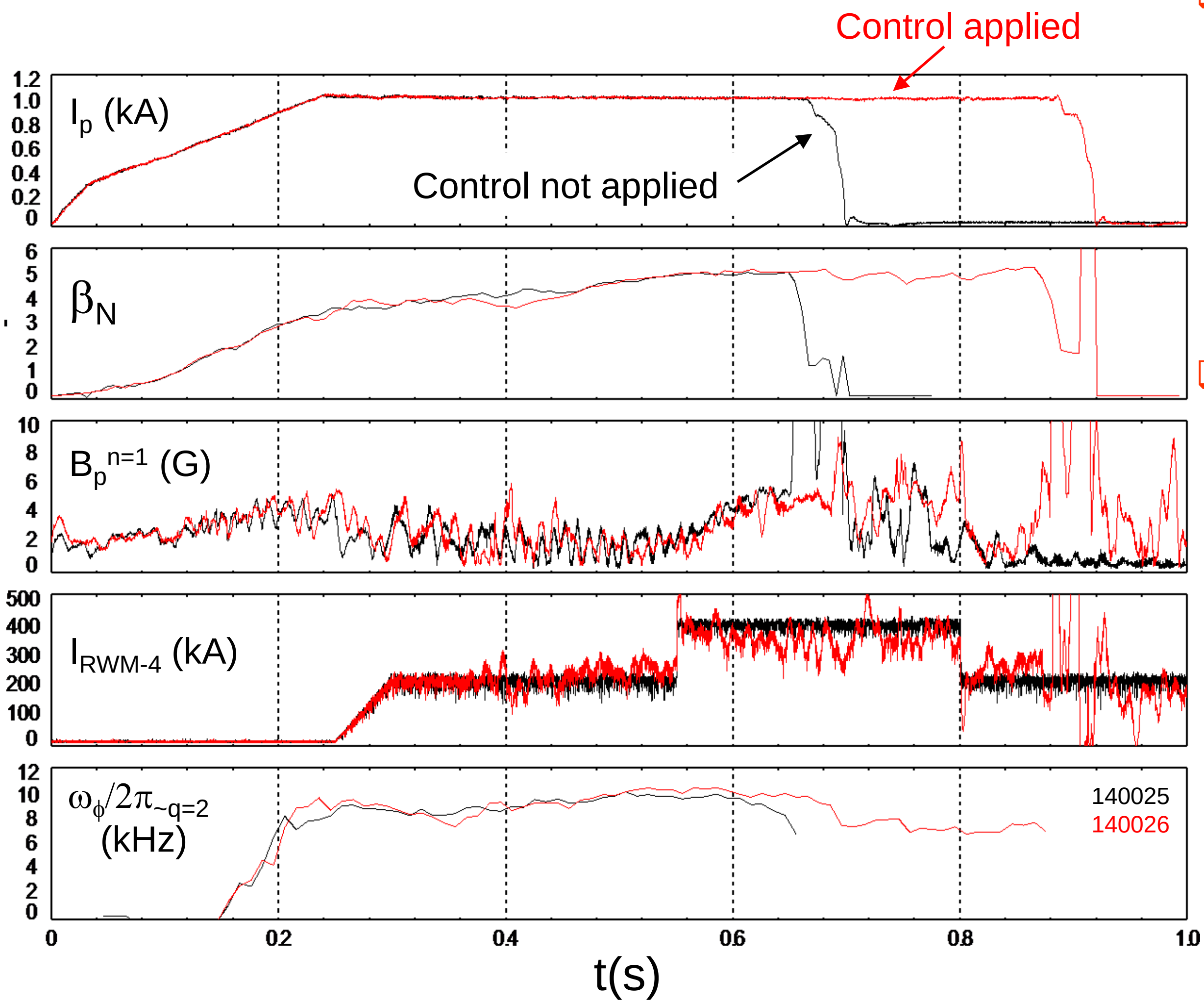
- R. Neu: Preparing scientific basis for all metal wall in ITER
  - rationale for choice of plasma PFCs
    - low power loss by dilution, long lifetime PFCs, low dust production, low T co-deposition, low Atomic number for low radiative losses
  - ITER PFCs
    - Be in main chamber, Tungsten main material in divertor, and C in divertor in transition region
  - Be influxes: large variation in experiments (by a factor of 10)
  - H retention reduced in all-Tungsten AUG
  - References:
    - Suttrop: AUG ELM mitigation (I2.109) – a highlight talk
    - Sips: JET DT (O5.127) – see comments by J. Hosea
  - Significant attention to first wall/materials in presentations at the meeting

- T. Pulkkinen: Plasmas in the Earth-Sun environment
    - Included magnetic reconnection and particle acceleration, solar cycle, solar wind composition, plasmas of inner magnetosphere, lack of thermal equilibrium (1 MFP = Sun-Earth distance)

# Comments on Some Stability Presentations (I)

- Stability Plenary Presentation was a Meeting Highlight
  - P. Martin: Near and beyond the limits: MHD stability and its active control
    - Basic concepts: stellarator/tokamak/RFP, ITER, equilibrium and magnetic perturbations in these machines, fast particle modes, $\beta$, fusion power gain
    - Disruptions: 4MN forces in JET, 40 MN forces in ITER - a significant concern
    - Resonant field amplification: example from JET
    - Instability avoidance / active control:
      - Conducting wall can stabilize kink/ballooning
      - Passive RWM stabilization: MISK results by Jack Berkery shown; DIII-D examples shown
      - Active RWM stabilization in
        - RFPs: RFX / EXTRAP-T2R: Modes not strongly coupled – large number (~ 150) control coils
        - Tokamaks: NSTX RWM state space controller highlighted
      - NTM control: sawtooth pacing to predict NTM onset, island phasing to match ECCD phase
      - ELM stability: non-linear stability work (JOREK)

# Piero Martin's talk showed NSTX RWM state space controller results as a highlight




- n = 1 DC applied field
  - Simple method to generate resonant field amplication
  - Can lead to mode onset, disruption
- RWM state space controller sustains discharge
  - With control, plasma survives n = 1 pulse
  - n = 1 DC field reduced
  - Transients controlled and do not lead to disruption
  - NOTE: initial run – gains NOT optimized

# Comments on Some Stability Presentations (II)

- I. Classen: Investigation of fast particle driven instabilities by 2D ECEI on AUG and DIII-D
  - Tutorial on *AE modes, ECE radiometer - principles of imaging, AUG ECE imaging diagnostic / similar diagnostic on DIII-D
  - Code results from: NOVA, TAEFL codes discussed (latter is a hybrid gyrofluid code), linear gyrokinetic LIGKA code
  - Change of frequencies measured between modes can be used to determine the q profile
  - Bursting modes - identified as BAEs and not off-axis fishbones
  - BAEs cause fast ion losses in AUG (energy and pitch angle resolved)

- Esposito: Disruption avoidance by means of ECE waves
  - localized ECRH/ECCD on rational surface, triggered by a disruption precursor - were able to hold of disruptions
  - AUG case ECCD triggered by Vloop, response time about 7ms
  - NTM mode locking is held off with ECRH
    - ECRH did not eliminate the NTM - just kept it from locking
    - change in density can spoof this - need to actively move ECE mirror if density changes, as reonance moves
  - AUG and FTU activities summarized
    - (AUG: r/t TORBEAM, r/t equil. recon., r/t mirror control, reliable operation above Greewald limit)

# Comments on Some Stability Presentations (III)

- R. Cavazzana: Physics challenges and answers in RFP MA operation
  - RFX MA operation - 48x4 independent active coils; transition to RFP helical equilibrium
  - MHD dynamo engine: tearing modes, multiple vs. single helicity states
  - key parameter for the helical state - dominant mode 1/7 vs. Secondary
  - results from RELAX (1/4 dominant) vs. MST (1/5 dominant mode)
  - control of m = 0 modes, lifetime of helical states

- I. Chapman: Sawtooth control in tokamaks
  - overview of sawtooth instability - good if short period, but may be long in ITER
    - may need to pace sawteeth for ash removal in ITER
  - long sawtooth period also leads to undesirable NTM triggering
  - trapped particles are stabilizing for kink (?)
  - co- and counter-passing ions can be stabilizing or destabilizing, depending on where fast particles are deposited
    - objective here is to destabilize the kink to drive sawteeth at higher frequency
  - code set being used for these studies MISHKA-HAGIS
  - will ECCD control work in ITER?
    - shear reduction as ECCD sweeps across q =1 surface, sawtooth period was changed in JET
  - will ICRH control work in ITER?
    - JET experiment was successful in not triggering NTM

# Presentation on ELM mitigation on AUG was a highlight

- W. Suttrop: First observations of ELM mitigation with new active control coils in AUG
  - 4 upper, 4 lower coils used in experiment (n = 2 configuration)
  - shows 0.1% field perturbation (see also Fuchs P1.090)
  - ELM mitigation shown with n = 2 fields
    - 2 periods of n = 2 pulses used - ELMs come back between pulses
    - in ELM mitigated periods, very much smaller ELMs are seen - very small density fluctuations (Te fluctuations are larger)
    - stepping up density with n = 2 coils on leads to ELM suppression
  - mitigation means Type-1 ELMs replaced by frequent small ELMs
  - pedestal density increase, T pedestal reduced by 10%, confinement/stored energy essentially unchanged
  - D pellet injection does not trigger ELMs in this state
  - there is a density threshold for ELM mitigation, independent of plasma rotation.
  - Key aspects are very different from DIII-D results:
    - there's a strong dependence on density
    - NO dependence on field (up/down) parity
    - NO dependence on q resonances
    - NO dependence on Chirikov parameter - NEITHER necessary NOR sufficient

# Comments on Some Stability Presentations (IV)

- A. Huber: Radiation heat loads on plasma-facing components of JET during the massive gas injection experiment
  - MGI valve mounted on the top of the machine on JET
  - strong poloidally asymmetric radiation peaking factors in JET
  - 10% Ar, 90% D2 injected - nearly poloidally symmetric radiation pattern
  - suggests that ITER will need 4 ports for MGI

- R. Scannel: Evolution of edge pressure gradient during ELM cycle - MAST
  - Notable - See comments by J. Hosea
  - EPED model (Snyder) applied to MAST, high-n stability, GS2 code to KBM stability analysis, also passed on to ELITE
  - single ELM cycles, examine/average many cycles - 50 profiles in 3 shots
  - points taken through the ELM cycle; ETB moves slightly inward as ELM cycle advances
  - edge high-n unstable region increases in size, from the edge inward - 99% flux to 97% flux, or so
  - GS2 run to give stability to KBMs - KBM had stabilizing FLR effects
    - stability limit falls during the ELM cycle, rather than the pressure gradient strongly increasing
    - claims that infinite-n is a GOOD proxy for the KBM stability in MAST (?)

# Comments on Some Stability Presentations (V)

- Tuesday posters – some highlights
  - Poster on 3D simulation of plasma interactions with edge structures in ITER
    - Electric fields cause relocation of hot spots on tiles
    - (comment) May need to alter edge field to prevent this – another potential use for internal non-axisymmetric coils in ITER
  - Liu MARS-Q code: momentum balance has been added, with a JxB and NTV torque model included

- Buratti: Kink and tearning modes in JET
  - kink transforms to island topology over long timescales
    - n =1 kinks onset from betaN about 1.2 - 4
    - high betaN, high pressure peaking, high qmin are less stable to kink
  - plasma crosses n = 1 no-wall limit when kink goes unstable
    - but what about at the lowest betas? A: the lowest beta cases don't cross the no-wall limit - they are tearing from the start - there is no kink phase.
  - shows ECE discrimination of kink vs, island, 150ms after kink, the island appears
    - Sweet-Parker time for forced reconnection is only 8ms
    - kink growth time is long - 70ms, so this is not thought to be a forced reconnection, but no theory was given to explain it

# Evening sessions had mixed reviews

- Welcome address (Monday): Madame Catherine Cesarsky (High Commissioner to Atomic Energy)
  - Relatively simple presentation for this venue
  - At least 3 European participants expressed embarrassment

- ITER session (Tuesday) (Motojima, et al.)
  - ITER first plasma delayed at least 1 year due to Japan earthquake/tsunami (coil construction delay)
    - "insiders" quoted at least 2 year delay
  - Non-axisymmetric coils still in design
    - Continued worry about cost overruns, and what might be cut
  - Compared to past talks, this one lacked energy a bit, and perhaps didn't inspire future researchers
    - Three young researchers questioned what they should be doing to stay in fusion research up to ITER first plasma

# General Comments on the Meeting

- Many of the contributed talks and posters did not draw clear conclusions
  - Many presentations could be called “work in progress”

- Excellent venue for poster sessions
  - Wide boards, landscape format, plenty of room (uncharacteristic for EPS), but…

- Poster sessions too short duration
  - 2 hours (!), and ~ 150 posters in a session
  - Scheduled “free time” after the 2 hour session was used to see more posters
    - or to present the two posters I was showing – each ran about 3.5 hours