Current PPPL Research Challenges & Opportunities in Macroscopic Stability

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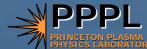
## **Overview of opportunities and challenges**

Perspective from IAEA/ITPA/ITER/BPO:
ELM control - 3D B-field effects on H-mode profiles
Role of MHD in J profile of "hybrid" scenario
Disruption mitigation physics
Resistive wall mode physics at low rotation

PPPL MHD strengths:
 Equilibrium & stability of non-axisymmetric plasmas
 Non-linear MHD simulations – M3D
 NSTX, DIII-D – test theory against experiment



Ideas for possible theory contributions (1) ELM suppression using 3D coils Use stellarator tools to better understand 3D equilibrium MHD stability and <u>transport</u> response to 3D perturbations Observe decreased pedestal density, similar/higher T Are edge field lines really ergodic? Why density pump-out? → Head start on transport analysis for NCSX MHD effects on current profile in hybrid scenario Extend ORBIT analysis: DIII-D (3/2 NTM), NSTX (core 1/1) Use birth distribution from TRANSP Investigate full orbit effects – is G.C. approximation valid? Reproduce measured NSTX ξ(r) with PEST or MARS? → Head start on predictive capability for other modes - \*AE



Ideas for possible theory contributions (2) RWM physics Study mode rigidity, RWM control with NMA code Longer term – couple GLF closures to C1-MHD code for 2fluid code with accurate low-collisionality damping models? Existing RWM damping models need improvement Develop new linear stability tool with broad applicability & usage... ITER disruption mitigation physics understanding Relies on edge cooling, 2/1 & 1/1 island formation, overlap Couple M3D to atomic physics package? (other ideas?)  $\rightarrow$  Not just for ITER – may need for any high-I<sub>P</sub> next-step



Ideas for possible NSTX contributions ELM suppression Revisit ELM mitigation experiments with RWM/EF coils Hybrid scenario physics Complete studies of core 1/1 mode interaction w/ fast ions Extend analysis to NTMs and/or high-f \*AE modes ITER disruption physics understanding Measure halo current, peaking, contribute data to ITPA RWM Test ITER RWM control models using NSTX RWM control tools and codes - compare VALEN, MARS-F, NMA?



**Possible RWM physics contributions** from DIII-D collaboration (Michio) Assess rigidity of RWM mode structure RFA eigenstructure, and during feedback at low rotation Incorporate poloidal non-uniformity of resistive wall, coils • Non-rigidity  $\Rightarrow$  MARS / VALEN discrepancy at C<sub>B</sub> > 0.7 ?? Assess with NMA code developed by Chance and Chu

**RWM/RFA** characteristics at low rotation Rotational stabilization window narrows at low rotation RFA more sensitive to details of plasma properties Reduction of rotation could cause ergodic regions to form Increased interaction of RWMs with ELM, NTM, SOLC

Simultaneous RWM feedback at minimum rotation Prototype ITER control system



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**Possible SOLC physics contributions** from DIII-D collaboration (Hiro/Eric) Scrape-off Layer Current (SOLC) studies: Now have good estimates of magnitude, spatial distribution DIII-D and NSTX 
 non-axisymmetry of this magnitude demonstrated to influence the stability of RWMs, ELMs

But, DIII-D tile current measurements disassembled...
 Should PPPL lead effort to revive & improve this system?

Physics experimentally & theoretically challenging...
 3D current on open field-lines – thermoelectrically driven?
 Include in RWM/ELM/NTM/EF/etc. (linear) stability calcs?



## Other considerations...

Why focus on "ITER-specific" issues like this?
One answer: We can lead the development of the scientific understanding of issues (thought to be) important for making ITER a success
Many of these issues are important beyond ITER

Still, should this be our priority?

Do not want to lose sight of MHD beyond ITER...
 High β, high rotation effects, etc. in ST
 Stellarator-specific MHD physics – disruption free?
 Advanced tokamak development for DEMO
 Other concepts – recent high-β FRC results

Suggestions for balancing these are welcome!



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