Discussion of Alpha Particle Physics Issues for AT Burning Plasmas

R. Nazikian

Princeton Plasma Physics Lab.

For the PPPL Science Focus Group

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J.W. Vandam (IFS)

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Single Particle Orbit and Loss in AT Regimes

- **Do AT regimes present a danger to first wall ?**
  - Expect enhanced transport for q(0)>1 (Redi)
  - Significant ripple loss expected in AT regime (White)
  - For 10% power loss, up to 4 MW alpha power to wall
  - Note: Neutron wall load $\approx$ 3 MW/m^2
- **R&D Issues I**
  - Need to accurately determine the peak wall power density
  - Need benchmark ORBIT loss predictions to experiment
  - Determine effect of collective instabilities on orbit losses
- **R&D Issues II**
  - Can or should orbit losses be controlled in FIRE?
  - Optimization of orbit loss being studied on JFT-2M (Sato)
    - Ripple induced loss reduced, edge rotation increased

Outstanding Issues in Collective Instabilities

- **The physics of the Beta Induced Alfvén Eigenmodes not well understood**
  - AT regimes exhibit mode activity inconsistent with ideal MHD
  - Present knowledge of such modes is incomplete
  - BAE motivates the development of hybrid kinetic-MHD codes
    - HINST (High-n stability) N. Gorelenkov
    - M3D (non-linear 3D kinetic-MHD) G. Fu

- **R&D Needs**
  - Alpha simulation experiments needed on present devices
  - Develop global non-perturbative eigenmode analysis
  - Quantitative benchmark to experiment needed on multiple machines

Non-linear TAE Physics and Enhanced Loss

- **Resonance Overlap of TAEs and enhanced loss**
  - Generic avelanche events and stochastic diffusion observed
  - Major progress in self consistent simulation of TAE bursts and intermittent particle losses (Todo)

- **R&D Needs**
  - Develop global non-perturbative eigenmode analysis
  - Quantitative benchmark to experiment needed on multiple machines
  - Projections to burning plasma

Alpha self-heating in AT regimes

- **Production and control of AT regime with dominant electron heating**
  - » ITB formation via ITG suppression observed on many devices with NB heating (ion channel)
  - » New evidence for ITBs with electron heating (FTU, DIII-D, C-MOD,…)
  - » Physics and scaling of such regimes are poorly understood

- **R&D Issues**
  - » RF & flow shear control of ITBs (via turbulence control)
    - • Local transport suppression leads to global improvement
  - » Physics of electron transport barrier formation
  - » Simulation of alpha heating and ITB formation

Final comments

The capability to explore AT regimes (high-beta/high-boot-strap regime including ITB) should be an essential part of the scientific mission of a next step experiment.

- single particle loss
- collective instabilities
- ITB formation and control

Diagnostics not discussed, But

Alpha diagnostics on a future Q=10 burning plasma will be much more difficult than in the TFTR- and JET-class D-T experiments (e.g., radiation damage, less access & less flexibility, high heat flux, large bremsstrahlung background & less pellet penetration).