Edge Turbulence at the H-mode Transition, Density Limit, and Beta Limit

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NSTX Forum
11/01

- Ideas
- Diagnostics
- Experiments
- Analysis

Ideas

Each of these phenomena may be caused by changes in edge plasma turbulence:

H-mode:

- self-organized Reynold's stress creation of shear flows from 3-wave coupling of turbulence to low frequencies [e.g. Moyer et al, PRL '01 p. 135001]

- change in edge turbulence parameters causes H-mode [Rogers and Drake, PRL '98, Xu et al IAEA '00]

Density Limit:

- increased penetration of high-level edge turbulence into closed flux surfaces -> increased edge transport -> thermal collapse -> density limit (schematic picture) [e.g. Greenwald, APS review talk '01]

- change in turbulence in (α, α_d) space causes density limit [Rogers and Drake, PRL '98]

Beta limit:

- high-n ballooning modes near edge set some theoretical beta limits [Paoletti NF 2001]

- external kink or ELMs may also have a role in limiting β

Edge Turbulence Diagnostics

Gas Puff Imaging (w/LANL):

- New “Phantom” camera at up to ≈ 10 kHz
- Improved 7-ch fast chords at up to 250 kHz
- PSI camera at up to 1 MHz (for ≈ 1 month)

USX array (JHU):

- Has seen edge “filaments” in Carbon IV, V

Fast Scanning Probe (UCSD):

- Profiles of density and Te in edge / SOL
- Edge turbulence (density, potential,Te)

Reflectometer(s):

- Edge turbulence system by UCLA
- Edge profile system by ORNL

Magnetics:

- Can see high-n modes, maybe turbulence

Experiments

- Measure structure of edge turbulence during XP's on H-mode, density limit, and beta limits
  - GPI can measure m ≈ 20-100 near outer midplane up to f ≈ 200 kHz
  - Use all available fluctuations diagnostics
  - Measure edge profiles as well as possible (Langmuir probe, TS, CHERS, Reflect.)

- After "piggy-backing" on other XP's, plan a dedicated XP which is optimized for edge turbulence and transport measurements
  - should not explore new parameter space
  - should do systematic scans with maximum diagnostic coverage

Analysis

- Analyze GPI images and times series e.g. using DEGAS 2 for images (Stotler)
- Evaluate edge turbulence characteristics vs. plasma conditions (ñ/n, k-spectra, etc)
- Use BOUT, BAL, MHD codes etc to calculate edge stability vs. plasma condition
- Compare turbulence measurements with edge stability calculations
- Try bicoherence analysis of data (UCSD) or other new statistical techniques
- Develop new measurements/experiments:
  - measure turbulence near X-point ?
  - measure turbulence near inner wall ?
  - measure edge magnetic turbulence ?
  - effects of NBI, ICRH, CHI, recycling, wall conditioning, wall biasing, etc ?