New findings on ELMs in ASDEX Upgrade

Edge Localized Modes

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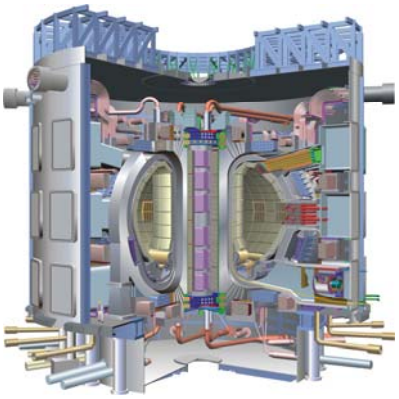
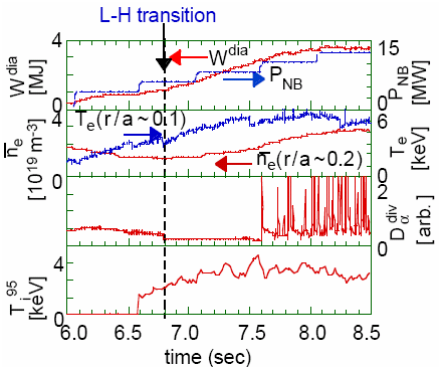
What is a Tokamak?

- **то**роидальная **ка**мера в **ма**гнитных **к**атушках
- Torus shaped fusion machine
- Toroidal field produced by coils
- Poloidal field produced by plasma current
- Heated with RFH (radio frequency heating), NBI (neutral beam injection) and Ohm's heating
- Examples: JET, ASDEX-U, ITER and many more.



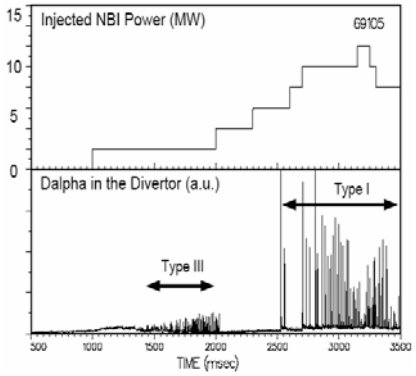
What is the H-mode?

- High confinement mode
- Better confinement of plasma and energy
- $P_{separatrix} > P_{threshold}$
- Reasons not clear
- Changes in flow profiles are suspected to be a reason



What is an ELM?

- "Edge Localized Modes"
- Sudden burst like in boiling water
- Fast loss of particles and energy
- Instability near the plasma boundary
- Only in H-mode
- No first principles theory



Classification of ELMs

- Type I ELM repetition frequency increases with P_{heat} , no magnetic precursor occurs, type I ELMs are isolated sharp bursts.
- Type II ELMs occur, if plasma with type I ELMs is changed to higher elongation and triangularity. No information on dependence on P_{heat}, and magnetic precursor exist.
- Type III ELMs repetition frequency decreases with P_{heat}, coherent magnetic precursor with oscillation frequency 50–70 kHz are observed.
- Type II and III ELMs are more grassy (Not sharp and isolated).

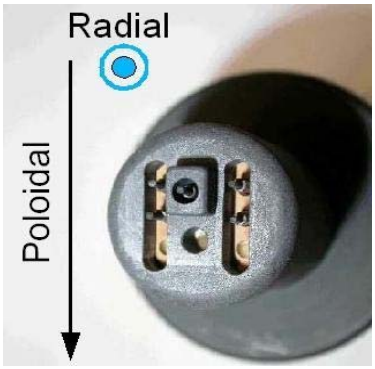
There are other classifications but they are not uniform.

Why is it so important to understand ELMs?

- In the ELMy H-mode, for example, the density can be controlled experimentally.
- ELMs limit the core plasma.
- Non ELMy H-mode plasma is not stable.
- Transition from type I to type II or III is important for experiments like ITER, because type I ELMs are expected to destroy the divertor plates.

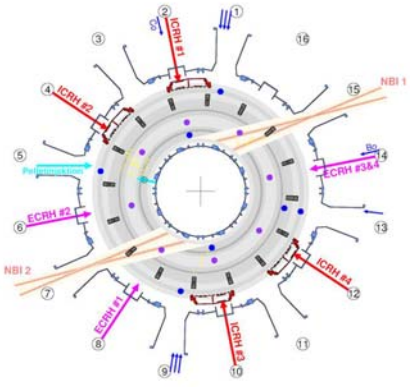
What did we measure?

- 3 floating probes (floating potential)
- 1 swept probe (characteristics)
- 1 negatively biased probe (-70V - ion saturation current)
- All probes had a temporal resolution of 2MHz.
- D_α signal
- Position of the probe



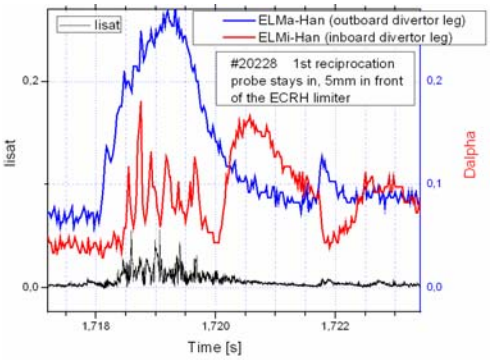
How and where did we measure?

- ASDEX-U on IPP in Garching
- Deuterium plasma
- Midplane manipulator
- Reciprocative probe head (nearest 5cm to separatrix)
- Carbon probes
- D=1mm
- L=2mm
- 5mm distance between them
- Section 8
- $T_e \cong 100$eV
- $B_{tor} \cong 2{,}3$T



What did we evaluate?

- Reynolds stress
  $R_e = \langle \tilde{v}_r \tilde{v}_\vartheta \rangle \cong \langle \tilde{E}_\vartheta \tilde{E}_r \rangle / B^2$
- Fluctuation driven flux
  $\Gamma = \langle \tilde{n}_i \tilde{v}_r \rangle = \langle \tilde{n}_i \tilde{E}_\vartheta \rangle / B$
- Cross correlation between these quantities
- Probability density function and cross coherence of Reynolds stress
- All derivation made between ELMs and during ELMs



What else do we want to evaluate?

- Probe characteristics from a swept probe
- Electron temperature in L-mode, during an ELM and between two ELMs
- Plasma potential
- Radial and poloidal velocity of ELMs
- Dimensions of ELMs

References

- H. Zohm: Plasma Physics and Controlled nuclear Fusion 38 (1996) 105–128
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- J. Wesson: Tokamaks
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- K. Tsuchiya: Substantial Reduction of H-mode Transition Threshold Power in JT-60U
- P. Balan: Investigation of Fluctuation in SOL of ASDEX Upgrade by Langmuir Probes