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Spontaneous and triggered abrupt and non-local reduction of electron heat and density fluxes and ITB formation in T-10 tokamak plasmas with ECRH/ECCD

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ABSTRACT

- During "global" L-H transitions found in various regimes of JET [1] and JT-60U [2-3] tokamaks earlier, the rise of Te,i and ne starts simultaneously in the spatial zone 0.3< r/a < 1, while heat and density fluxes fall simultaneously in the same region.
- At the ITB-events in JT-60U and T-10, heat and density fluxes fall in internal spatial zone within ≈50% of the minor radius.
- At the new transitions discussed below (W limiter with Li-coating), Te starts to rise at 0.2 <r/a<0.6 similar to its behaviour during an ITB-event and leads to ITB formation.
- The new semi-global transitions looks as ITB-event at Te and "global" L-H transition on density. Heat and density fluxes fall simultaneously at 0.3< r/a < 1. Spontaneous single and dithering transitions occurs at simultaneous co+contr ECCD/ECRH only. Triggers of the transitions are neon gas puffing and spontaneous drop of Li-containing flake at various ECCD/ECRH. The transition triggered by neon gas puffing is not the transition to RI-mode since the radiation losses are small enough and start to rise just prior to the transition.
- An abrupt increase of energy confinement time at the moment of the transition is around 15%

BACKGROUND

- The typical value of the H-factor in limiter tokamaks with cylindrical cross-section is low enough (e.g. at JFT-2M [4], JIPP T-IIU [5] and TEXT-U [6]).
- The rise of Te in the internal part of plasmas was mentioned at L-H transitions in circular tokamaks with the limiter JIPP T-IIU and TEXT-U .The rise of Te in the internal part was reported also at L-H transitions in T-10 [7] at off-axis ECRH only. The similar phenomenon was triggered by pellet injection at many tokamaks and by spontaneous drop of carbon flake into NBI-heated TFTR plasmas. Nevertheless, analysis of the non-locality of the electron heat flux jump was not done.

Experimental setup

T-10 tokamak

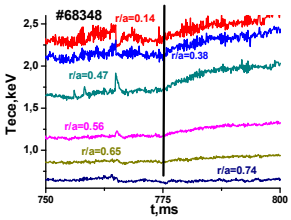
R = 1.5 m, ***a*** = 0.3 m, $\mathbf{B_0}$ = 2.4 T

ECRH/ECCD(140 GHz-two gyrotrons;130 GHz-one gyrotron)

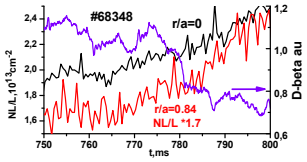
OUTCOME

1. Spontaneous Semi-Global L-H Transitions occurs at co+contr ECRH/ECCD with 1.5 MW by two gyrotrons only.

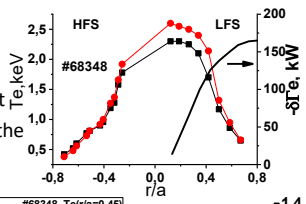
Te starts to rise simultaneously at 0.25<r/a<0.6. ITB forms gradually after transition.



All interferometer channels starts to rise at the same time. Dbeta starts to falls.

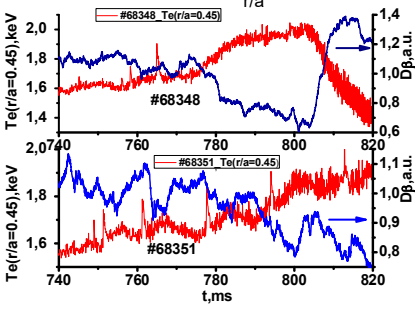


Te profile measured 20 ms after transition shows ITB-formation at LFS and HFS. Electron heat flux reduces at 0.3<r/a<1. The significant rise of density strongly affects the profile of heat flux jump δΓe. At all T-10 cases reported below the rise of density significantly affects the profile of δΓe at periphery.



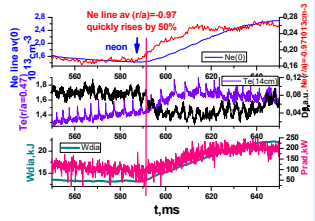
τE abruptly rises by 15%

Comparison of single and dithering transitions. Te rises simultaneously with the drop of Dbeta during at least 5 H-mode phases (5-10 ms).

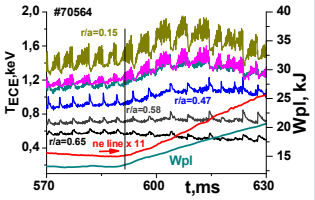


2. Transition Triggered by neon gas puffing at P=0.85 MW

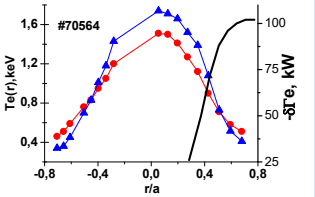
The edge density start to rise 30% faster compare Internal interferometer channels. Radiation losses just are small and enough and start to rise just prior to the transition (not RI mode).
Experiments of:
- KIRNEVA N.A. et al, EPS 2018
- KASYANOVA N.V., RASUMOVA K.A. et al, EPS 2018



Te starts to rise simultaneously at 0.25<r/a<0.6. ITB forms gradually after transition.

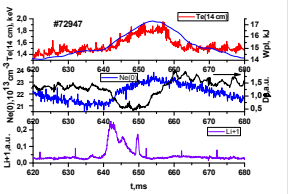


Te profile measured 20 ms after transition shows ITB-formation at LFS and HFS. Electron heat flux reduces at 0.3<r/a<1. The significant rise of density strongly affects the profile of heat flux jump δΓe.
- τE abruptly rises by 20%



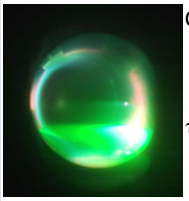
3. Semi-global L-H transition by spontaneous drop of Li-flake

Radiation losses are small and enough and start to rise just prior to the transition.
The density starts to rise 2 ms after beginning of ionization of Li-flake.



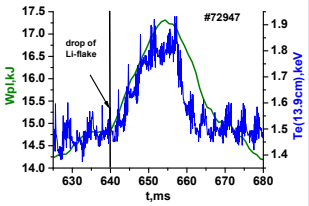
Exact correlation of Te and Wpl.

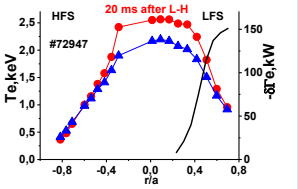
CCD camera image 2 ms after the start of ionization of Li-flake (at L-H)



Clear ITB formation on Te

τE abruptly rises by 15%





CONCLUSION

The new semi-global transitions looks as ITB-event at Te and "global" L-H transition on density. heat and density fluxes fall simultaneously at 0.3< r/a < 1. Spontaneous single and dithering transitions occurs at simultaneous co+contr ECCD/ECRH only. Triggers of the transitions are neon gas puffing and spontaneous drop of Li-containing flake at various ECCD/ECRH. An abrupt increase of energy confinement time at the moment of the transition is around 15%. The accumulation of impurities is absent.

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