

Effect of the Dynamic Ergodic Divertor in the TEXTOR Tokamak on MHD Stability, Plasma Rotation and Transport

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Relevance of magnetic field stochastization in ...

stellarators: characteristic magnetic island structure in island divertor \rightarrow high density H-mode

- tokamaks: (non-linear) interaction internal / external helical modes effect of magnetic field stochastization
 - \rightarrow NTM mitigation
 - \rightarrow ELM mitigation

External helical magnetic field perturbation

- mitigation of undesired instabilities
- control of edge transport
- avoidance of undue heat loads reaching plasma targets

- deterioration of confinement (heat and momentum transport)
- excitation of instabilities

Dynamic Ergodic Divertor in TEXTOR (R = 1.75 m, a = 46 cm)



Magnetic field topology





m/n = 3/1



Plasma rotation and transport <u>below</u> threshold for tearing mode excitation (m/n = 3/1)

Plasma parameters do not change up to a certain perturbation threshold (static DED)

except toroidal rotation



94087

0

2

0

3

2



Drop of thermal plasma energy by 12%



Below threshold for tearing mode excitation toroidal plasma rotation increases in cocurrent direction



... independent of DED rotation direction and net angular momentum input



 \rightarrow only level at which tearing mode is excited differs

- increase of toroidal rotation only scales with level of ergodization (I_{DED})
- increase of corresponding $v_{\phi} \times B_{\theta}$ is consistent with E_r generated by a preferential loss of electrons (but no global confinement change)
- observed \mathbf{v}_{ϕ} is in $\mathbf{E}_r \times \mathbf{B}_{\theta}$ drift direction
- run-away electrons show prompt loss when DED is switched on



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- run-away electrons show prompt loss when DED is switched on
- no viscosity effect energy confinement does not change
 - ω_{ϕ} increases even at zero net angular momentum (balanced NBI)
- direct indications for E_r from probe and correlation reflectometry measurement, but only when tearing mode is excited



Floating potential from rake probe

E_r from poloidal correlation reflectometer

Plasma rotation and transport <u>above</u> threshold for tearing mode excitation (m/n = 3/1)

Above certain threshold external perturbation (m/n = 3/1) excites m/n = 2/1 tearing mode



\rightarrow MHD rotation locks to external perturbation

\rightarrow Toroidal plasma rotation slows down

Strong m/n = 2/1 sideband favors excitation of corresponding tearing mode



To avoid disruption $q_a \ge 4.5$ required

Clear evidence for formation of tearing mode (locked magnetic island)



Dependence on initial plasma rotation (before mode excitation) depends on sign of rotation



Conclusions

 Magnetic perturbation field (m/n = 3/1) of the Dynamic Ergodic Divertor increases plasma rotation independent of angular momentum input and direction of perturbation field rotation

 \rightarrow under which conditions plasma braking or acceleration ?

- A tentative explanation is the ergodization of the plasma boundary which by an enhanced electron loss and the ambipolarity constraint generates a radial electric field
- With the (static) DED tearing mode stability can be controlled
 - Excitation threshold of *m/n* = 2/1 tearing mode (by *m/n* = 3/1 perturbation) depends on sign of initial plasma rotation (also dependence on density and β)

\rightarrow influence of rotational shear, mode spectrum on coupling mechanism, NBCD ?

- Stabilization with ECRH (ECCD)
- Stabilization of intrinsic tearing modes (m/n = 3/1) by imposing a higher harmonic (m/n = 12/4)

Reproducible excitation of tearing mode allows study of mode suppression by ECRH



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m/n = 12/4 perturbation (static) stabilizes intrinsic m/n = 3/1 tearing mode



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Discussion

Resonant mode amplitudes

m/n = 3/1

m/n = 12/4



Tearing mode excitation threshold depends on ...

density

β



Reproducible excitation of tearing mode allows study of mode suppression



ECRH deposition scan (mode suppression)



Impurity transport with DED



Electron heat transport with DED (ECR heat pulse modulation)



Evidence for tearing modes (SXR emission)

