P3.06

CONSORZIO RFX
Ricerca Formazione Innovazione
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Electron thermal conductivity in presence of Internal Transport Barriers in the RFX-mod Reversed Field Pinch

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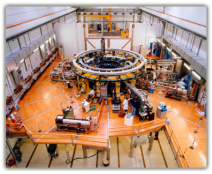
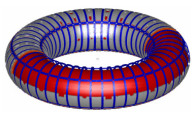
RFX-mod (R_0 = 2 m, a = 0.46 m) located in Padua, Italy is the largest Reversed Field Pinch presently in operation

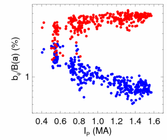


RFX-mod has two unique features:
– it can reach I_p up to 2MA
– it has the most advanced feedback coil system ever realized in a fusion device

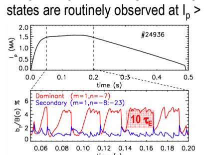


4×48=192 feedback saddle coils independently controlled and respective sensors

When I_p increases the amplitude of the innermost resonant mode (m=1, n = -7) increases and eventually saturates while the secondary modes decrease. [P. Piovesan et al., NF 49, 085036 (2009)]

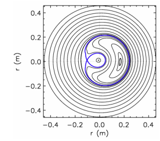


Long lasting **Quasi Single Helicity (QSH)** states are routinely observed at I_p > 1MA.

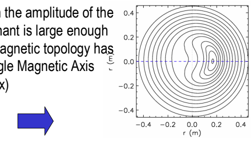


Theory and 3D MHD codes describe a helical ohmic equilibrium self-sustained by a single mode.This is the chaos-free **Single Helicity (SH)** state. [S. Cappello et al., PPCF 46 B313 (2004)]

The plasma dithers between **QSH** and **MH** (Multiple Helicity) state but QSH phases become **more frequent, longer and purer** increasing I_p

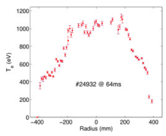


When the amplitude of the dominant mode is large enough the magnetic topology has a Single Magnetic Axis (SHAx)



SHAx states are known to be resilient to the magnetic chaos [D. F. Escande et al., PRL. 85, 3169 (2000)]

In the **SHAx** we observe the onset of an **electron internal transport barrier (e-ITBs)** surrounding a large fraction of the plasma volume where the profile is nearly flat [R. Lorenzini et al., PRL 101, 025005 (2008)]

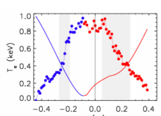


The magnetic topology of a SHAx is well described in terms of the helical flux χ_{mn} (m=1,n=7)

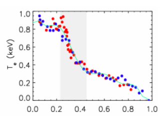
Equilibrium — Dominant mode

$$\chi_{mn}=m\Psi_0 - nF_0 + (m\psi_{mn} - nf_{mn})\exp i(m\theta - n\phi)$$

The mode eigenfunction is calculated using Newcomb's equation + edge B measurements [P. Zanca & D. Terranova, PPCF 46 1115 (2004)].

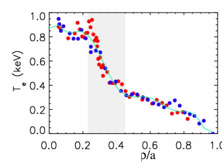


T_e is a function of χ_{mn}



Analogous conclusion holds [R. Lorenzini et al., Nature Phys. 5, 570 (2009)]:
- for soft X-ray measurements
- electron density when significant gradients are induced in the core thanks to pellet injection

The analyses presented here regard a database of about 100 T_e profiles with e-ITB, measured by means of 84 points TS.



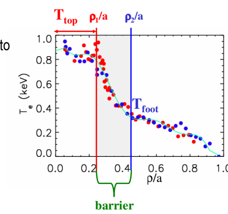
The **SHEq code** [E. Martines et al., submitted to PPCF] calculates the equilibrium and the flux surface averages.

The 1.5D transport **code ASTRA** has been interfaced to SHEq, and is used to study the energy transport.

The radial coordinate is the **effective radius** $\rho = a(\chi/\chi_0)^{1/2}$

To chacterize the barrier it is useful to define

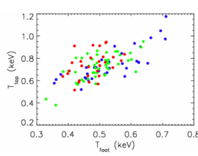
- ρ_1, which is the position where the flat part of the profile ends and the gradient starts
- ρ_2, which is the foot of the barrier, namely the position where the gradient ends
- T_{top}, which is < T_e > where ρ < ρ_1
- T_{foot}, which is < T_e > at ρ ~ ρ_2



The range of I_p of the database is 800 kA <I_p <1.8 MA

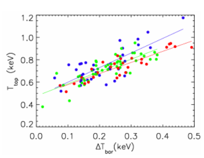
The range of n_e of the database is $1.2e^{19}m^{-3}$ <n_e <$6e^{19}m^{-3}$

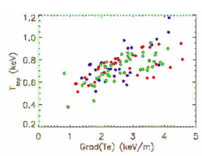
T_{top} increases together with T_{foot}



T_{top} is also an increasing function of $\Delta T_{bar}=T_{top} - T_{foot}$ and of grad(T_e)

Highest T_{top} correspond not only to the highest T_{foot} but also **to the steepest gradients**

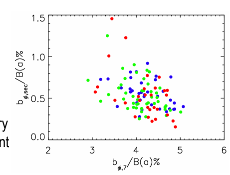




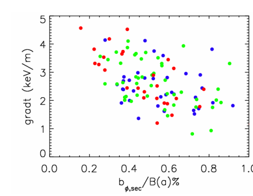
The aim of the analyses is to study **the dependence of the energy transport** from the **magnetic chaos** generated by secondary modes

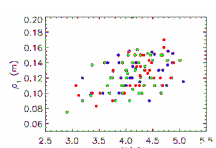
As expected the amplitude of the **dominant mode** and the energy of **secondary modes**, resonating close to the barrier (m=1, n=8-12), **are inversely correlated.**

Hence it is often difficult to separate the effect of secondary modes from that of the dominant one.



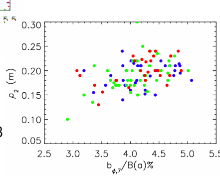
The temperature gradient depends on the secondary modes.

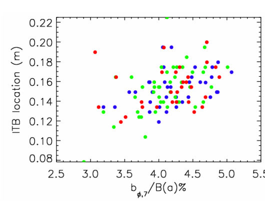




When the amplitude of the dominant mode exceeds 4% of the total field the maximum radius of the flat part of the profile saturates at about 0.15 m

The data suggest that when the amplitude of the dominant mode exceeds 4% of the total field the most external position of the e-ITB foot saturates at 0.24 m

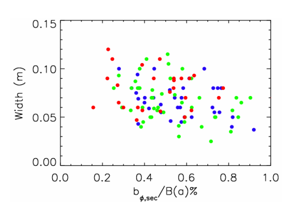




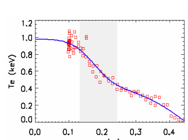
The **ITB location**, defined as the radius of the maximum grad(T_e),shows a dependence on the amplitude of the dominant mode **analogous to that of ρ1 and of ρ2**

The parameter ***Width***=ρ_2-ρ_1 measures the **radial extension** of the e-ITB.

Width shows a weak dependence on secondary modes: the maximum extension reaches ~ 0.1 m

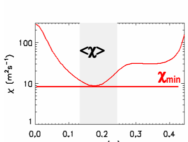


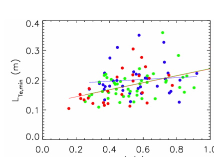
The Thomson Scattering data are interpolated by the ASTRA code



ASTRA is used to calculate the thermal conductivity by means of the power balance

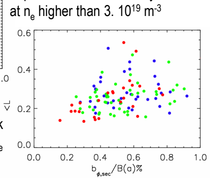
The effect of the magnetic chaos is studied by means of the dependence of χ_{min} and of the <χ> on the energy of secondary modes which resonate close to the barrier.





The minimum value of Te scale length $L_{Te,min}$ shows a weak dependence on secondary modes at n_e higher than 3. 10^{19} m^{-3}

The average value <L_{Te}> inside the barrier of T_e scale length shows a weak dependence on secondary modes at n_e higher than 3. 10^{19} m^{-3}



It is difficult from these data to draw a definite conclusion on the presence of an additional transport mechanism gradient lenght driven.

This question remains open