Profile reflectometry on TORE SUPRA

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• 50-75 & 75-110 GHz X mode reflectometers
• Deleterious effect of the magnetic ripple
• Profile reconstruction
• ECE noise during LH heating
• Front face LH antenna reflectometer
• Additionnal perspectives for swept systems
TORE SUPRA

50-75 & 75-110 GHz X mode reflectometers

TORE SUPRA:
R=2.4m; a=0.75m; Bmax=3.85T

Reflectometer dedicated for edge profile measurements

- Sweep time = 20 μs
- S/N ~ 40 dB
- Beat frequencies 0 - 50 MHz
Deleterious effects of the magnetic ripple (1)

\[ \delta B/B \text{ ripple on TS } \sim 7\% \]

Phase scrambling
Amplitude losses
Deleterious effect of the magnetic ripple (2)

Simulation of the beam propagation under toroidal ripple conditions

Lost of reflected signal is a combination of magnetic ripple & density gradient effects
Deleterious effect of the magnetic ripple (3)

- S/N improved by 15 to 30 dB
- Appearance of a very low density plasma at the edge
Profile initialisation

Initialization is achieved at the first cut-off \((ne=0; F_{1st}=F_{ce})\) from the reflected amplitude signal.

The density profile is conveniently initialized from the low density plasma edge.
Profile reconstruction (1)

- X mode propagation is a function of B

- Initialization always done with the V band set-up
Profile reconstruction (2)

Comparison
reflectometry / interferometry

Supersonic gas injection

1 profile every 70 µs

\( ne(R) \)

\( P_{\text{FCI}} = 3 \, \text{MW} \)
TS30414
745 MJ / 4 mn 25

(Long duration discharge)
ECE noise generated by supra thermal electrons

Suprathermal electrons generated by lower hybrid power create a relativistic downshift of the Fce inducing an ECE noise below the first cut-off.

- ECE noise overcomed
- Critical choice for the antenna set-up
The reflectometer is located at the antenna rear while the wave is launched through Ka waveguides.

Waveguide coupling used for reference signal.
LH antenna reflectometer: results on plasma

- Difficulty to filter out multi-reflexions
- Rapid loss of reflected amplitude

Multi-reflections between the front face antenna and the plasma may perturb the profile reconstruction
Extended perspectives for swept reflectometry: MHD

MHD -> density plateau -> group delay modulation

Profile simulation with localized Gaussian shaped perturbation

Group delay modulation

Frequency (GHz)

Group delay (ns)

Experiment

q=2/1

Burst mode operation

Dynamic of the mode

~8 kHz
Extended perspectives for swept reflectometry: micro-turbulence and $k_f$ spectrum

$$\Phi(F) = \Phi_0(F) + \delta \Phi(F)$$

\[\tilde{S}(k_r) = \left| \text{FFT} (\delta \Phi(R)) \right|^2\]

$\Phi(F)$

$\Phi_0(F)$

$\delta \Phi(F)$

$\tilde{S}(k_r)$

$2k_{\text{MAX}} \sim 15 \text{ cm}^{-1}$

Extended perspectives for swept reflectometry: turbulence profile

TS X mode reflectometry → Radial profile of fluctuations

\[ \delta R = 2 \text{ cm} \quad k_{\text{min}} = 3.1 \text{ cm}^{-1} \]
Summary

- Routine profile reconstruction from shot to shot
- Profile reliability ~ 100 %
- Beware of the edge magnetic ripple!
- Suprathermal ECE parasitic noise overcomed
- LH antenna reflectometry suffers parasitic reflections
- Relevant informations on MHD activity & micro-turbulence