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Large m/n = 2/1 modes observation in TEXTOR-94 plasmas.

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1. Introduction.

MHD modes influence transport in tokamak plasmas and need further understanding to develop disruption prevention schemes. Investigations of plasma confinement inside the magnetic islands with respect to the background plasma were performed on TEXTOR-94 tokamak by means of various microwave diagnostics [1,2]. To make quantitative analysis of the MHD phenomena, new systems with high temporal and spatial resolution have been installed. The temperature profile perturbations due to MHD modes in TEXTOR-94 plasmas can now be measured in more detail by fast Electron Cyclotron Emission (ECE) diagnostics. Perturbations in the electron density profile at the low field side (LFS) can be studied by a fast ten-channel pulsed radar reflectometer. A high-resolution Thomson scattering system provides snap-shots of the temperature and density profiles throughout the magnetic islands. The first results of MHD phenomena studies with new and upgraded diagnostics are given in this paper. The detailed analysis will be done in the nearest future.

2. Experimental set-up.

The present ECE diagnostic configuration on the TEXTOR-94 tokamak (R_0 = 1.75 m, a = 0.46 m, B < 2.9 T) covers the frequency range of 96 – 180 GHz. An 11-channel X-mode radiometer with a spectral range between 105-145 GHz and an intermediate frequency (IF) bandwidth of 200 MHz is used to measure routinely the electron temperature profile with a sampling rate of 10 – 20 kHz. It is absolutely calibrated by means of a hot-cold source, positioned in the tokamak vessel during machine venting. Three six-channel spectrometer systems are covering three separate frequency bands of 104 – 114, 125 – 130 and 133 – 148 GHz with a sampling rate up to 2 MHz. Under standard plasma conditions the radial locations of the six-channel spectrometers are in the vicinity of the rational q-surfaces. The main aim of the spectrometers is to perform high-resolution localised measurements of MHD phenomena [1].

An O-mode pulsed radar reflectometer with the frequency range of 18 – 57 GHz is installed to measure density perturbations for up to ten different densities simultaneously, at a repetition rate of 2 MHz, or a subset of those channels at up to 10 MHz repetition rate. The reflectometer can simultaneously measure the full density profile at the LFS of the plasma as well as perturbations due to the islands.

A new high-resolution Thomson scattering system with a spatial resolution of $\Delta z/a < 2\%$ and accuracy $\Delta T/T < 5\%$ and $\Delta p/p < 3\%$ at density $n_e = 5 \bullet 10^{19}$ m^{-3} is being used to study small scale structures in the electron temperature and pressure. The system is based on a ruby laser and can measure two profiles during the discharge at 50 – 500 μs interpulse time.

3. Experimental results and discussions.

The effects of large magnetic islands in the vicinity of the q = 2 magnetic surface is observed by the ECE systems, pulsed radar reflectometer (see Fig. 1) and the Thomson scattering (Fig. 2). The MHD oscillations are seen both the high and low field sides by the 11-channel radiometer (Fig.1, a) in plasma with $B_T = 2.24$ T and density $n_e = 2.5 \bullet 10^{19}$ m^{-3}. A local temperature peaking inside the m = 2 magnetic island can be seen on the ECE time traces at the LFS (Fig.1, a, black arrow). The pulsed radar reflectometer traces (Fig. 1, b) shows channels which are monitoring the density layers just above (39 GHz) and below (29 GHz) the island. The discontinuity in the pulsed radar signals is explained by the fact that the rotating island has a peaked density profile. As a result of this the reflectometer signal is alternately reflected from the

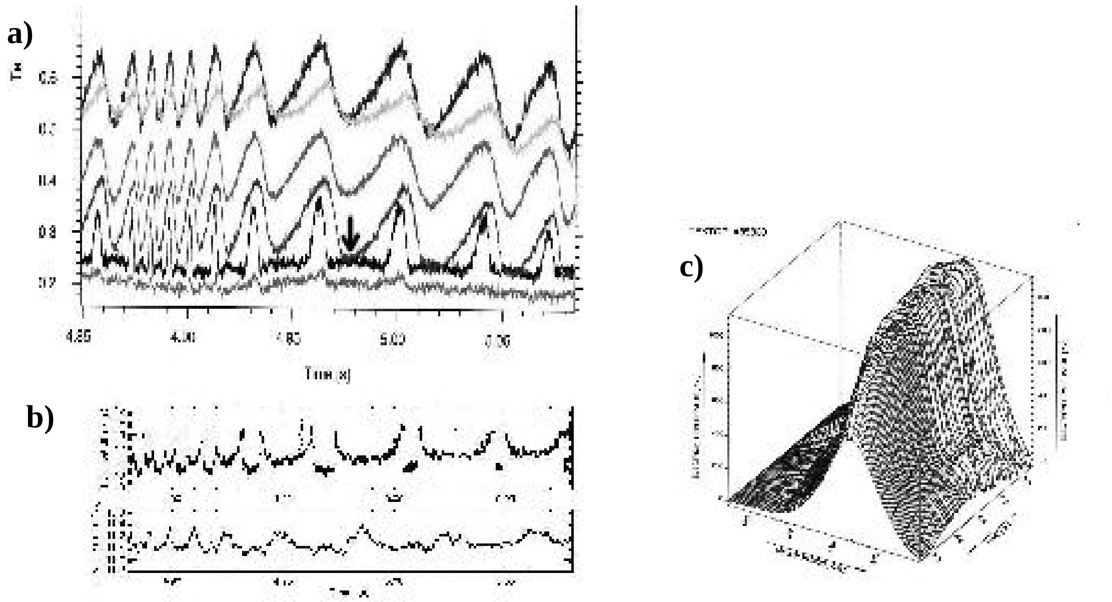

Figure 1. A dynamic non-harmonic behaviour of modes detected soon after switching off NB at 4.5 s. The 11-channel radiometer (a) as well as pulsed radar reflectometer traces (b) (signal offsets are not calibrated) shows MHD oscillations at the q=2 vicinity both from LFS and HFS. A local temperature peaking is observed inside the m=2 island at the LFS and indicated by the arrow on one of the ECE traces (a). A density peaking inside of the island is observed by the pulsed radar reflectometer (b). The 3-D plot (c) shows the location of the m=2 island in the plasma.

island and from the density layer behind it. The three-dimensional contour plot of the temperature throughout the plasma is given in Fig. (1, c): the m = 1 and m = 2 modes activity can be clearly distinguished. A dynamic non-harmonic behaviour of modes is detected soon (≈ 0.45 s) after switching off the neutral beam (NB) heating at 4.5 s (Fig. 1, a, b). The m = 1 and m = 2 mode coupling can be a possible explanation for such kind of phenomena.

Another observation of m = 2 mode activity is made with the ECE diagnostics and with Thomson scattering for a plasma with B_T = 2.04 T and density $n_e = 3.0•10^{19}$ m^{-3} (Fig. 2, a, b). The temperature peaking up to 0.3 keV as well as the density peaking up to $0.5•10^{19}$ m^{-3} inside the island with respect to the X-point is seen at the time ~ 3.17 s (Fig. 2, a, upper and middle profiles). One can estimate the magnetic island width from Thomson scattering data: it is approximately 5 cm, in good agreement with earlier measurement [2]. The contour plot (Fig. 2, b) for the time interval of 3.1 – 3.2 s gives information about the temperature distribution and localization of the large m = 2 modes in plasma.

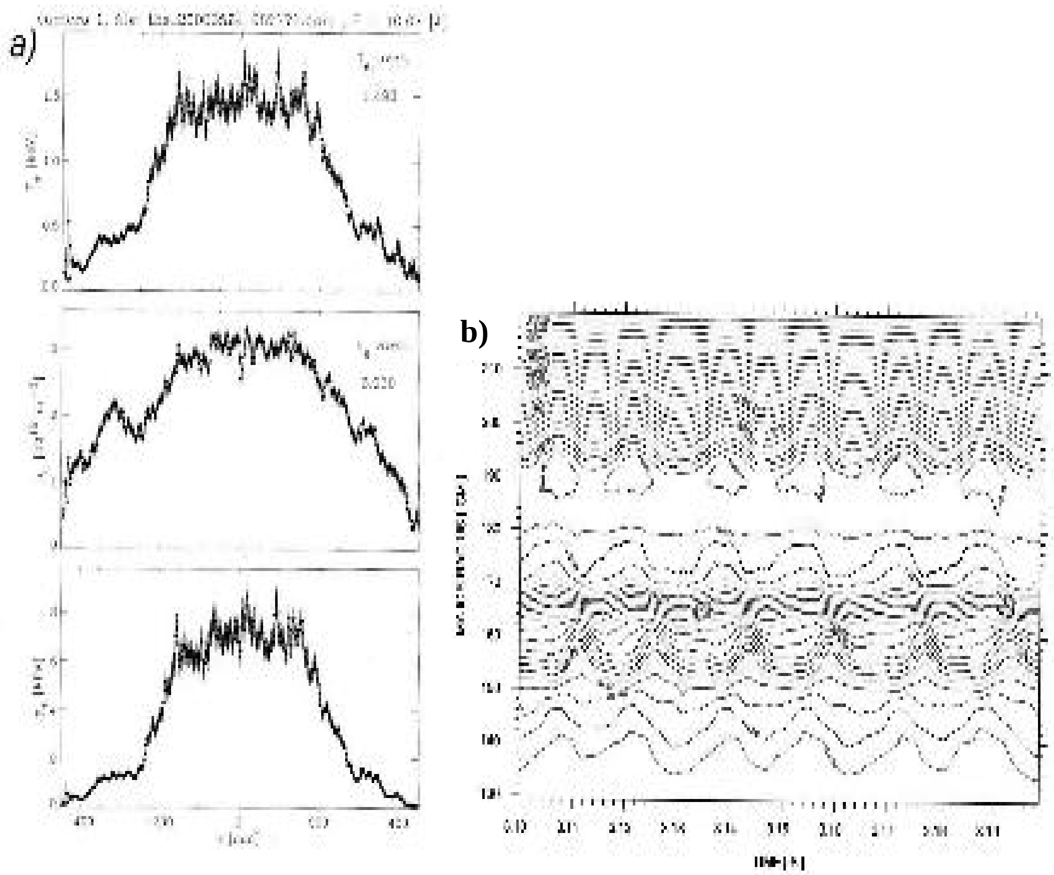

Figure 2. Large m=2 mode observation with Thomson scattering and ECE systems. Thomson scattering profiles (a) shows local temperature and density inside the magnetic island (upper and middle profiles). The bottom signal is the pressure profile. An estimation of the magnetic island width can be made: it is approximately 5 cm for this shot (B = 2.04 T, $n_e = 2.5•10^{19}$ m^{-3}). ECE temperature contour plot (b) help to determine the location of the large m=2 islands. The peak on one of the ECE signals at ~ 3.13 s is due to the electronic hardware of the system.

3. Conclusion.

Various TEXTOR-94 diagnostics (e.g. ECE systems, pulsed radar reflectometer, Thomson scattering) make it possible to study MHD phenomena in plasmas such as large m = 2 modes, with a good temporal and spatial resolution. A temperature and density peaking inside of the magnetic islands is observed. The width of the typical island is identified as ~ 5 cm from ECE and Thomson scattering data. A new

16-channel frequency-tunable heterodyne radiometer is being installed exactly during the 27th EPS Conference in Budapest and, therefore, first results with this system are not yet available. The ultra-high resolution of the combination of the new 16-channel radiometer and three existing six-channel spectrometers will provide in future the possibility to get temperature profiles within the magnetic islands and the additional means to measure microscopic temperature fluctuations throughout the plasma.

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