Characterisation of the edge region of the RFX-mod device

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The reversed field pinch experiment RFX-mod (R=2 m, a=0.5 m) is equipped with a large number of active external magnetic coils for MHD mode control[1], allowing the realisation of a virtual shell.

In the present paper the first characterisation of the edge region of RFX-mod is presented in terms of electrostatic and magnetic parameters measured locally.

The edge region of RFX-mod is investigated by means of several diagnostics.

A structure supporting a two-dimensional array of electrodes allows the measurement of the electron density and temperature, of the plasma potential and of all three magnetic field components. The diagnostic, named "U-probe", is made of two identical boron nitride cases, each housing eight toroidal arrays of five electrodes

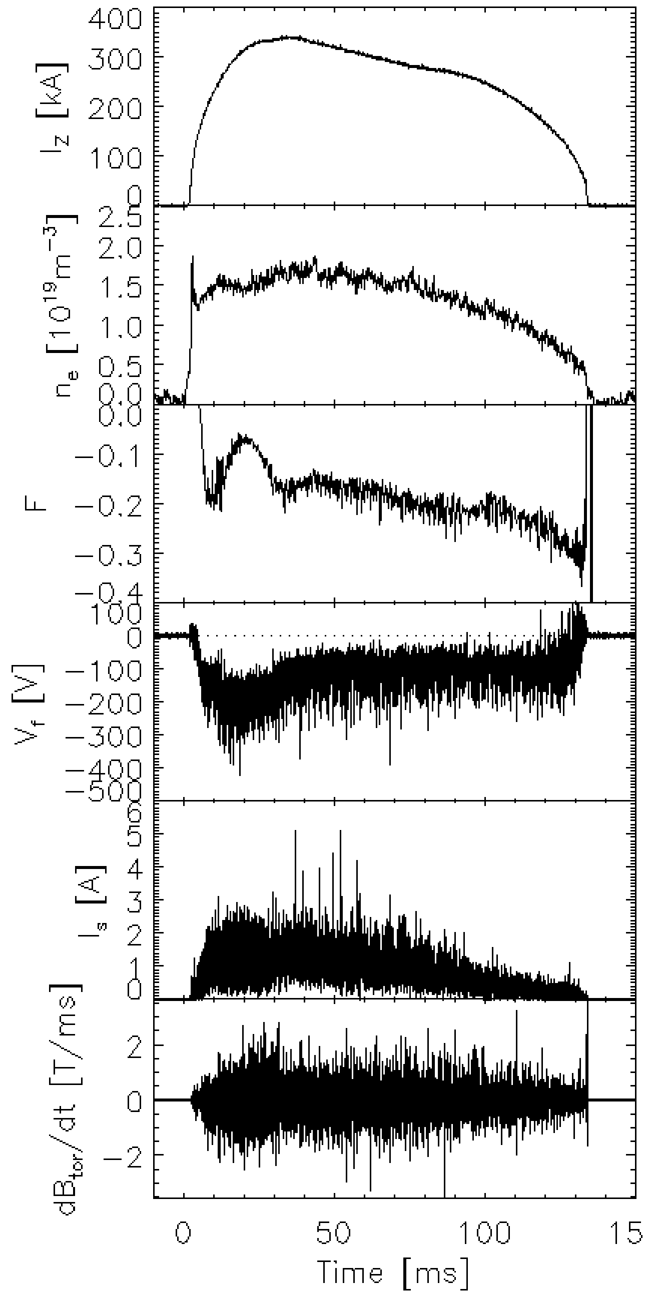

Fig 1

(total of 80 electrodes); inside each case, a radial array of 7 three-axial magnetic coils is located (total of 42 magnetic sensors). Both in the toroidal and radial directions, the distance between the sensors is 6 mm. This system provides a limited radial profile of the parameters in a single shot and a complete radial profile on a shot-to-shot basis. The diagnostic is installed on a manipulator[2] providing its insertion into the plasma through an outer equatorial port. Electrostatic data were transferred to the acquisition system and isolated by electro-optical conversion; magnetic data were taken directly to the acquisition modules. In all cases the bandwidth was about 1 MHz and the sampling frequency 5 MS/s. During the present campaign some electrodes and magnetic coils belonging to the Integrated System of Internal Sensors (ISIS)[3], have also been used. The electrodes are located on either side of the port-hole used by the U-probe. The magnetic coils are at the same toroidal position as the U-probe, but 90° poloidally spaced.

Toroidally spaced by 15° a gas-puff imaging diagnostic (GPI)[4] was located on an outer equatorial port. For the present purpose, it will suffice to mention that 16 lines of sight view the light emitted by helium gas puffed into the edge of the plasma. The lines of sight were 6 mm toroidally spaced from each other.

All these diagnostics have been simultaneously used in low current discharges in which the virtual shell was adopted to control the magnetic field configuration at the edge of the plasma[5]. Main parameters were: plasma current of 300-350 kA, electron density of 1-1.8·10^{19} m^{-3}, reversal parameter F = -0.2; fig. 1 shows an instance of

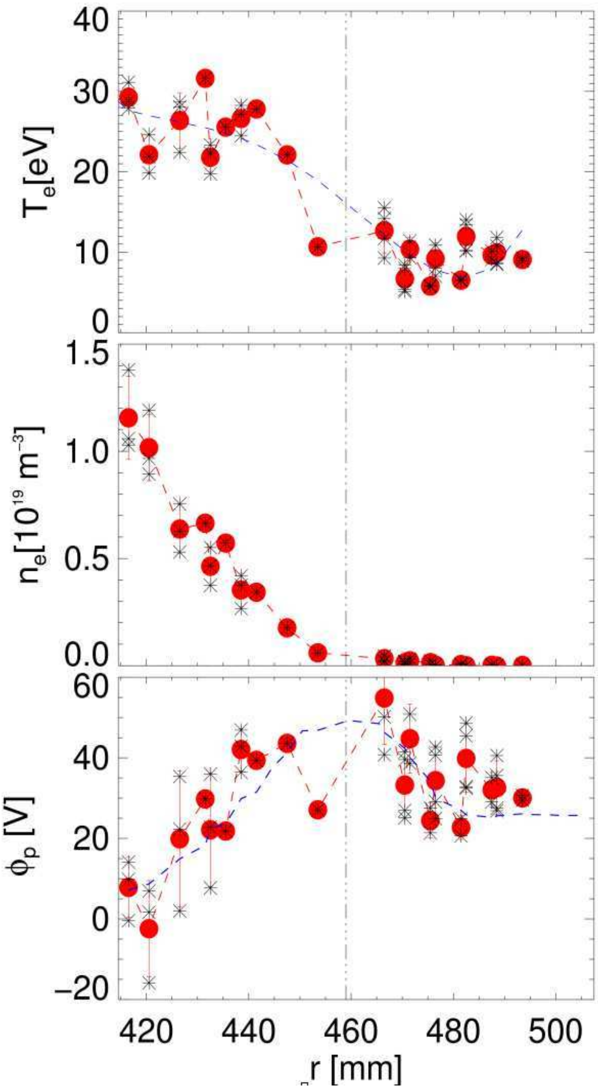

Fig. 2

plasma current, plasma density, floating potential, ion saturation current and time derivative of the toroidal magnetic field component. The analyses referred to in the following have been carried out during the current flat-top phase.

Fig. 2 shows the profiles of electron density and temperature and plasma potential. It can be noticed that the density displays an exponential behaviour in the port-hole (scrape-off layer), whereas it increases linearly in the plasma edge with a gradient of about $3 \cdot 10^{20}$ m^{-4}, similar to RFX[6]; the temperature increases from 10 to 30 eV in the same region.

From the radial gradient of the plasma potential the radial electric field is computed, whence the toroidal **E**×**B** velocity is obtained, shown in fig. 3. A double shear structure can be detected in the radial profile of the toroidal velocity as already known in the previous RFX machine. The value of the innermost shear is $4 \cdot 10^5$ s^{-1}, comparable to earlier measurements in RFX[7].

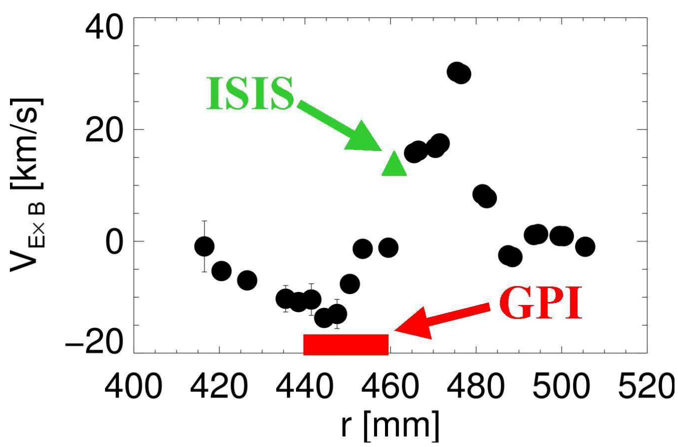

Fig. 3

The toroidal velocity can be estimated in various ways. When the same quantity is measured in more than one spatial location, the cross-correlation can be computed for all possible pairs of measurements. The slope of the time lags at the maximum of the cross-correlation as a function of the distance yields an estimate of the propagation velocity of fluctuations; using floating potentials, such estimate resulted comparable to the **E**×**B** velocity in the past[8]. This method has been applied to the GPI lines of sight, yielding the mark shown in fig. 3; it must be remembered that the radiation collected by the lines of sight represents an average over the emitting region, which extends radially about 20 mm in the edge plasma. The slope of the power

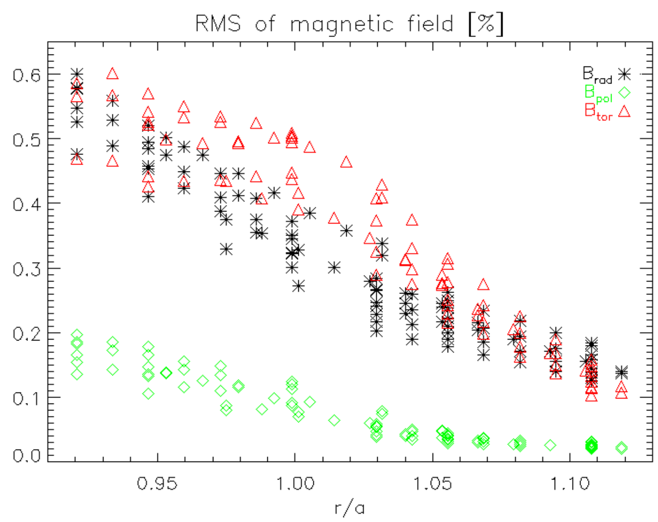

Fig. 4

spectral density $S(k,f)$, where k is the wave-number and f the frequency, provides an estimate of the phase velocity of fluctuations[9]. $S(k,f)$ has been computed for the signals of magnetic field measurements of ISIS, yielding the point shown in fig. 3. All measurements provide comparable results for the toroidal velocity.

The radial profile of the rms value of the three magnetic field components is shown in fig. 4; all values have been normalised to the average poloidal magnetic field. The rms has been computed on the signals after high-pass filtering at 10 kHz. An increase can be noticed on all signals when entering the plasma. In particular in the toroidal field a strong reduction is observed as the measurement is performed in the port-hole (r/a = 1). The absolute value of the radial component is lower than in the previous machine[10] probably due to the combined effect of lower plasma current and the use of the virtual shell[5].

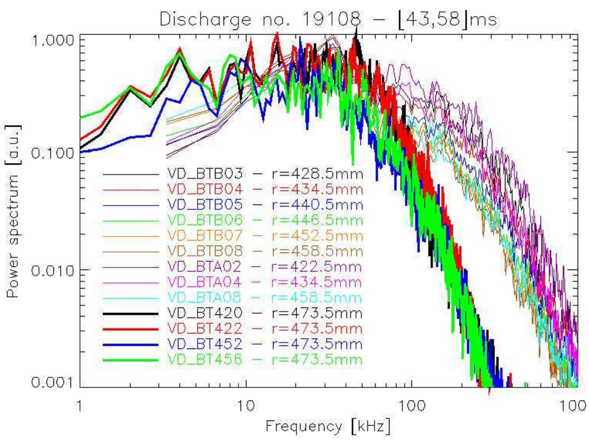

Fig. 5

In fig. 5 the power spectra are shown for the toroidal component of the magnetic field as measured by the magnetic coils of the U-probe and of ISIS; the curves have been normalised to the maximum of the spectra for each type of sensors. It can be noticed that the slope at high frequency is similar, though the ISIS spectrum is depressed, due to the in-vacuum cablings. Moreover, the radial decay of the magnetic field is apparent, confirming the results of fig. 4.

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