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Radial and toroidal electric field measurements in front of the CASTOR tokamak LH launcher

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Well localized spots ("Hot Spots") with considerably enhanced surface temperature and/or brightness are observed in large tokamaks on the parts of the walls connected by magnetic field lines with the region of the lower hybrid (LH) launchers, if power of MW's order is used for the non-inductive electron current generation [1,2]. Theory explains this undesirable effect by a parasitic production of fast particles, just in the nearest vicinity of the mouth of LH launchers (grills) [3].

Direct local measurements of the plasma parameters and properties of the electric field in this interaction region, by using Langmuir probes, are hardly possible in big machines. However, they are routinely carried out in small tokamak CASTOR at plasma duration 15ms and with the LH power of the order of tens of kW only. Floating probe potential measurements carried out on this tokamak revealed a substantial negative drop (potential "well") if LH power is applied. This negative "well" has been found in several mm thick radial layer only, just in front of the CASTOR grill and it has been interpreted as the existence of fast accelerated electrons [4]. Quite recent measurements on this machine [5] confirmed even other prediction of the theory about the positive plasma biasing in this region (resulting from the fast electron escape), using a single emissive probe measuring directly the plasma potential (if the insulated probe is heated to be emissive enough, its potential is approaching to the plasma potential, see [6]).

This contribution describes changes in radial profile of the floating potential V_{fl} and the plasma potential V_{pl}, if LH power is applied, by using of system of two identical emissive probes. Further, an evaluation of the toroidal electric field, detected by this probe system, is performed. The probes are made from a thin, directly heated (by DC current 7A), tungsten wire loops in a form of half circle with diameter less than 1.5mm. The both loops are located on the same magnetic surface (in a mutual toroidal distance 5.8 mm) and in this way an extreme high radial resolution of the system, given only by wire diameter (0.2mm), is achieved (toroidal resolution is much worse, given by the loops diameter). The probes are moved together in the poloidal plane and their radial position is changed from shot to shot by the step 0.5mm. All measurements have been done in front of the central waveguide of the three-waveguide multijunction CASTOR grill (the grill mouth is circularly shaped with radius 86mm). Sampling rate of all signals is 1MHz.

Fig.1 compares the changes in radial profiles of V_{fl} and V_{pl} for two values of LH power (10kW and 20kW). The profiles are yielded on the shot-to-shot basis utilizing the good repeatability of the CASTOR discharges by averaging over 500 samples just before (i.e. in ohmic discharge phase, diamonds) and just after application of the LH power (asterisks). Note that corresponding values of V_{fl} and V_{pl} are obtained in two different tokamak discharge pulses (probes are either not heated or heated during the whole discharge). It may be seen that depth of the radially narrow potential "well" formed in the V_{fl} profile several millimetres in front of the grill (ascribed to the existence of accelerated electrons) increased roughly proportionally to the power, without any visible radial shift of the "well" with the power. In contradiction to this effect, V_{pl} exhibits an increase, especially near to the grill mouth with r=86mm. Formation of a stationary radial electric field in this region up to

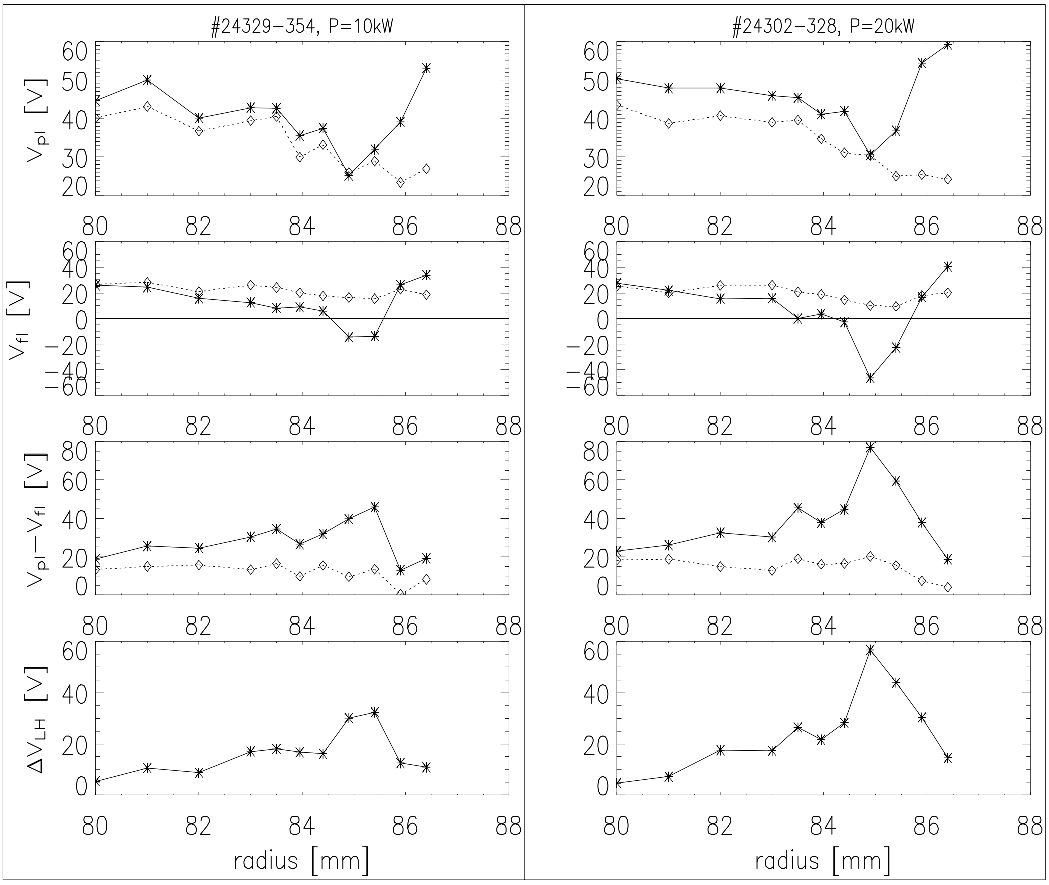

Fig. 1. *Radial profiles of the emissive (V_{pl}) and the cold (V_{fl}) probe floating potentials in OH (diamonds) and LH (asterisks) discharge phase (left–10kW, right-20kW of LH power).*

value 25kV/m can be deduced. Obviously, the positive plasma biasing results from the charge separation due to the escaping accelerated electrons [3]. Difference V_{pl}-V_{fl} (quantity proportional to the electron temperature in the Maxwellian plasma), substantially enhanced just in the "well" of V_{fl}, is given in the figure as well. To see better the net effect of the LH power, the change of this difference V_{pl}-V_{fl} during LH, comparing to the OH phase, denoted as ? V_{LH} , is shown as the last trace. Value of ? V_{LH} can be taken as a measure of the departure of the electron distribution function from the Maxwellian one (due to the creation of the non-thermal accelerated electrons). Concentration of this effect in the layer with thickness several mm only just in front of the grill is well visible.

Result of an attempt to determine time behaviour of the toroidal electric field E_{tor} at three characteristic radii (deeper in the plasma, at the "well" and at the grill mouth, see Fig.1) is given in Fig.2. The quantity E_{tor} is taken simply as the difference of the two heated probes potentials, divided by the probe toroidal distance (i.e. 5.8 mm). LH power is applied at 9ms. Comparing the E_{tor} in the OH phase (the signals before the 9^{th}ms) and in the LHW phase (the signals after the 9^{th}ms), a substantial increase of E_{tor} amplitude is observable in the region near to the grill mouth, i.e. just in the supposed region of electron acceleration,

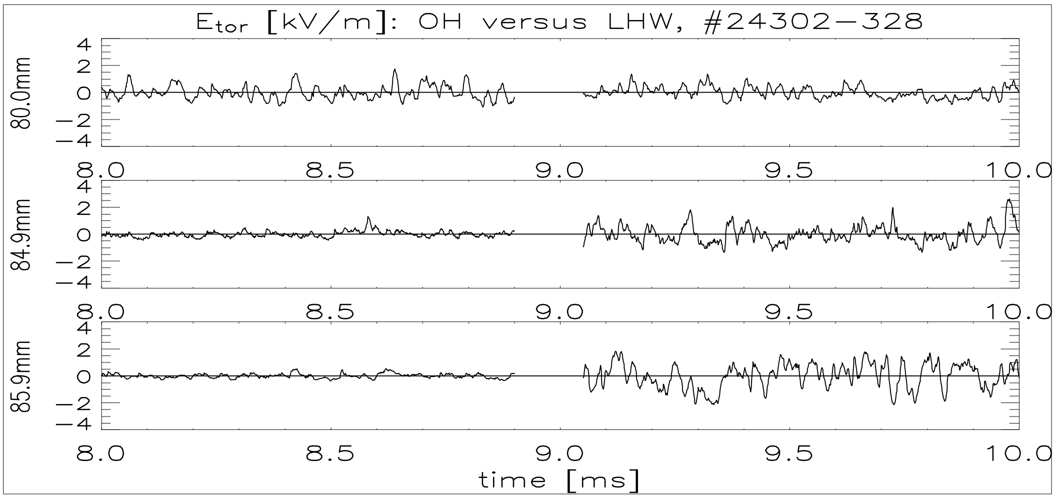

Fig. 2. *Time dependences of the toroidal electric field E_{tor} during the OH and the LHW discharge phases, found at three characteristic radii, see Fig.1.*

if LH power is applied. This fact is documented quantitatively better in the following Fig.3, where frequency spectra of E_{tor} are given in the logarithmic form S~ f^{-a} (again, comparison of the spectra in OH and LHW phases at the same three radii as given in figure 2). While no difference in character of fluctuating toroidal electric field spectra is seen deeper in the plasma (neither in parameter a, nor in the spectrum amplitude), formation of strongly enhanced E_{tor} (increase of the spectrum amplitude), just in the region of the fast electrons

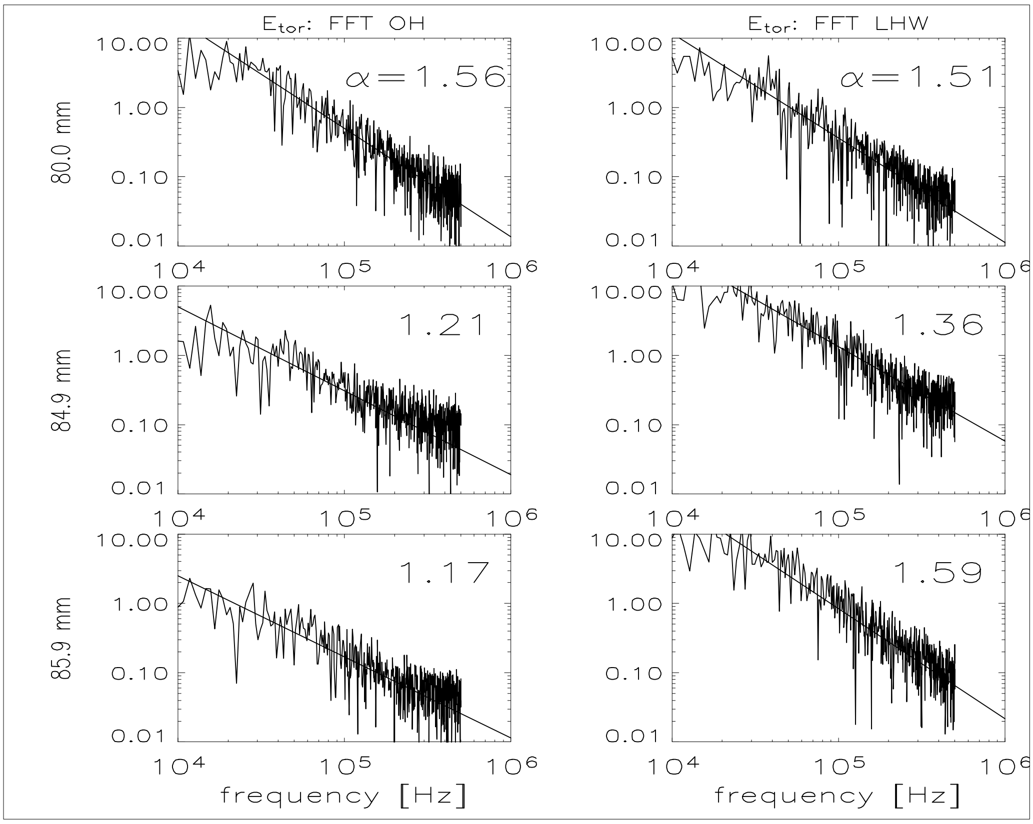

Fig. 3. *Comparison of toroidal electric field frequency spectra for OH (left) and LH (right) discharge phases. The spectra are evaluated for the same probe radii as given in Fig.2.*

occurrence (radii near to the grill mouth), is well visible. Because such toroidal electric field should be responsible for the enhancement of electron acceleration [3] by random fluctuating fields [7,8], this fact can be taken as an other experimental proof of the acceleration mechanism suggested by the theory [7,8]. Moreover, increased value of the parameter a indicates a more coherent character of the E_{tor} spectra in the region of the supposed interaction (the signal is less “noisy”).

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