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SUPPRESSION OF MAGNETIC FLUCTUATIONS BY LOWER HYBRID CURRENT DRIVE ON THE CASTOR TOKAMAK

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ABSTRACT. Preliminary observations of the effect of lower hybrid current drive on magnetic turbulence in the CASTOR tokamak are summarized. If waves drive 50% of the total plasma current the level of broadband magnetic turbulence is suppressed by a factor of 2-3.

INTRODUCTION

The effect of lower hybrid current drive (LHCD) on MHD activity has been observed on a number of tokamaks. On ASDEX [1], sawtooth oscillations was suppressed by LHCD simultaneously with observed broadening of current density profile and disappearance of q=1 surface. On PLT [2], m=1 mode was suppressed despite of $q(0)<1$. On PETULA [3], the growth of m=2 mode was stopped and maintained at low saturated level. This was also explained by a broadening of current profile, especially by decreasing of its gradient at q=2 surface. In all above experiments, LHCD caused suppression of coherent MHD activity what is in agreement with theory as a result of change in current density profile [4].

Some theories, however, predict that LHCD can affect the turbulent MHD activity through the more local mechanisms as a change of current density inside the m=2 island [5] or an asymmetry of electron distribution function which increases the level of electrostatic electron turbulence what has damping effect on $m\geq 2$ tearing modes [6]. The suppression of magnetic turbulence by LHCD in experiment was reported from the DITE tokamak [7]. This report presents the similar effect observed on the CASTOR tokamak.

EXPERIMENTAL SET-UP

Experiments was performed on the CASTOR tokamak having the major radius R=0.4 m and radius of aperture limiter a=85 mm. The RF power (40 kW, 1.25 GHz) is launched into the plasma through the 3-waveguide multijunction grill with the phasing -90, 0, +90 degrees and the width of each waveguide of 14 mm. Such grill has broad space spectrum (Nz=1-4) and rather low directivity (70%).

The MHD activity is monitored by a set of Mirnov coils placed in one diagnostic port at the radius b=96 mm (Fig.1.). The coils have the length of 30 mm and diameter of 6 mm and detect poloidal component of magnetic field. Signals from probes are processed by a passive low frequency filter and operational amplifiers so that the detected frequencies are from 100 Hz to 300 kHz (Fig.2). The detection possibilities are limited by seven A/D converters with sampling 0.5 μs and 4090 points per channel.

Some effect on detected signals can be caused by sector of stainless steel liner (minor radius=100 mm, thickness=0.5 mm, skin time=1/398 kHz) and copper shell (inner radius=117 mm and thickness=10 mm).

RESULTS

The typical effect of LHCD on magnetic turbulence is shown in Fig.3. The relative drop of loop voltage UL indicates that at t=26 ms half of the plasma current Ip is driven by waves. At the same time the level of MHD activity is suppressed by a factor of 2-3.

Because of limited memory, the Fig.3 shows magnetic fluctuation signals only during the transient phase which lasts appr. 2 ms after RF power is switched on. Then follows the phase which starts by a first larger and then by a repetitive Parail-Pogutse instabilities. During each such event, considerable part of energy is lost from the plasma (determined from Shafranov shift). It is, however, interesting to note that the level of MHD activity immediately before and after the instability is roughly the same (Fig.4).

Fig.5 shows the dependence of fluctuation level on poloidal angle. Despite of some modulation, the relative decrease (OH/LHCD-level divided by OH-level) is poloidally independent. This fact exclude the posibility that the change in fluctuation is caused only by a movement of particular magnetic surface relative to the probe as a result of increase of plasma energy during LHCD.

The fast fourier transform (FFT) spectra of probe signals are shown in Fig.6. Each curve is an average of 28 FFT spectra of 1000-point time series taken from seven coils (as in Fig.5) and from two shots. It is seen that the effect of suppression takes part in a broad frequency range. Therefore, in our case, LHCD has influence on the turbulent state of plasma. It is evident on the detailed temporal evolution of fluctuating part of magnetic field signal (Fig.7) which has low coherence for both OH and OH/LHCD cases.

The determination of mode structure from polar diagrams is limited by the low resolution in poloidal angle. An accidental inspections of diagrams at certain times shows a complicated mode behavior; at some instants m=2 and 3(?) modes can be recognized (Fig.8) which, however, live much more shorter than their revolution period. Some information can be obtained calculating the cross-correlation integral of signals from two probes shown in Fig.9. Each curve is an average of 12 cross-correlations of 1000-point signals from pair of probes separated by a poloidal angle 45 deg. In both OH and OH/LHCD cases it is observed a structure rotating in the electron diamagnetic drift direction with poloidal angular velocity 1.6x10+5 rad/s. In the OH regime, the structure has partially sinusoidal character with respect to the angle between the probes in contrast to the OH/LHCD case when it fully losts this feature.

CONCLUSION

We observed that if LH waves drive part of plasma current the level of magnetic turbulence is suppressed in a factor of 2-3 in a broad frequency range. At present, we do not know the mechanism of this effect in our experiment. The profile measurements can distinguish whether it is the result of change in current profile or of a more detailed mechanisms as quoted in introduction.

Independently on this, it is known that combined OH/LHCD plasmas exhibit larger energy confinement time. It would be interesting to examine if in OH/LHCD experiments confinement time correlates with the level of magnetic fluctuations as it is in heating experiments.

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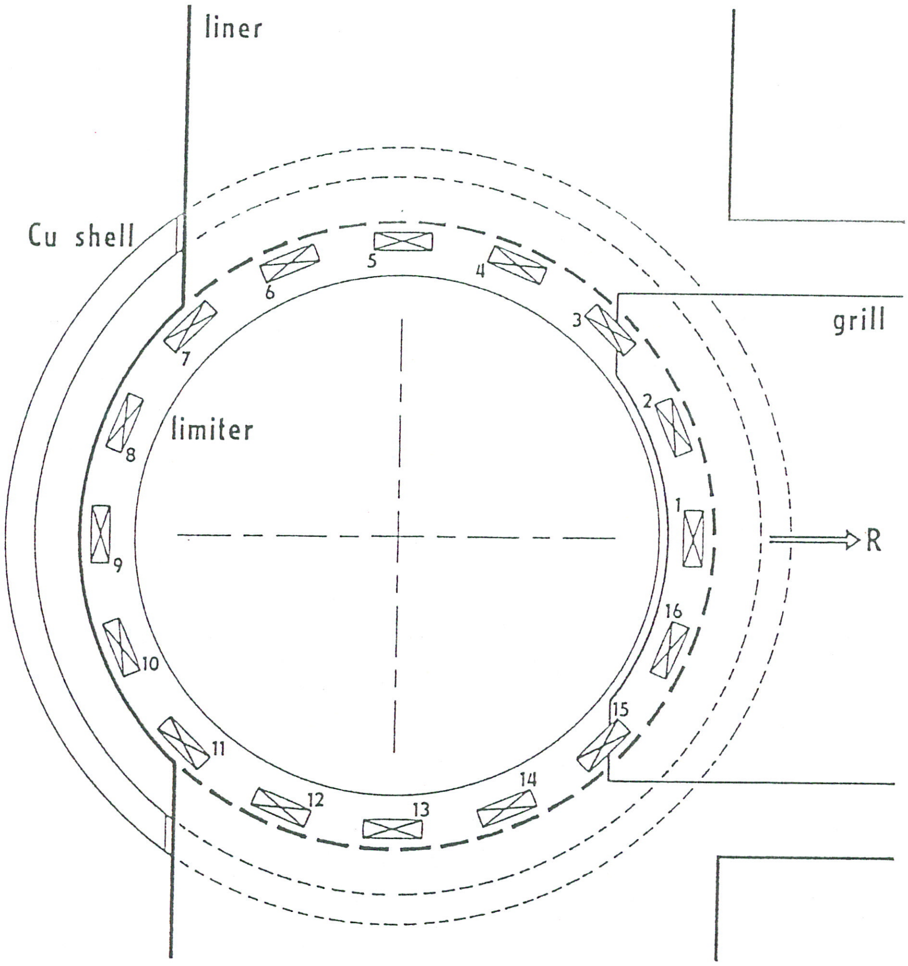

Fig.1 Experimental arrangement.

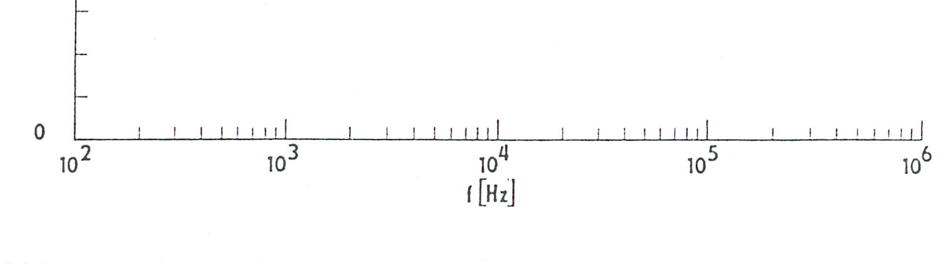

Fig.2 Attenuation of the circuits (low frequency filter and amplifier) between probe and A/D converter.

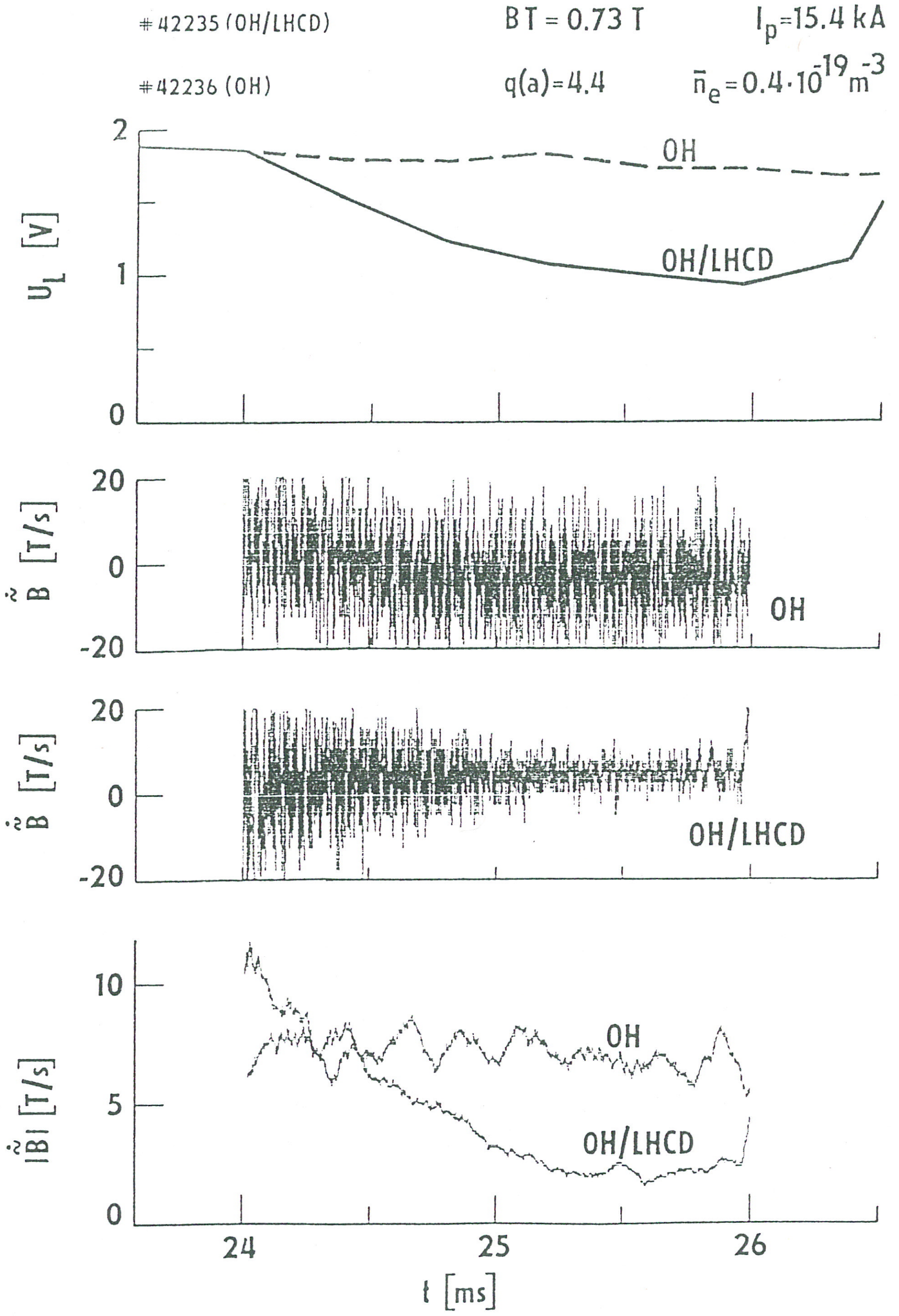

Fig.3 Effect of LHCD on MHD activity detected by probe 14.

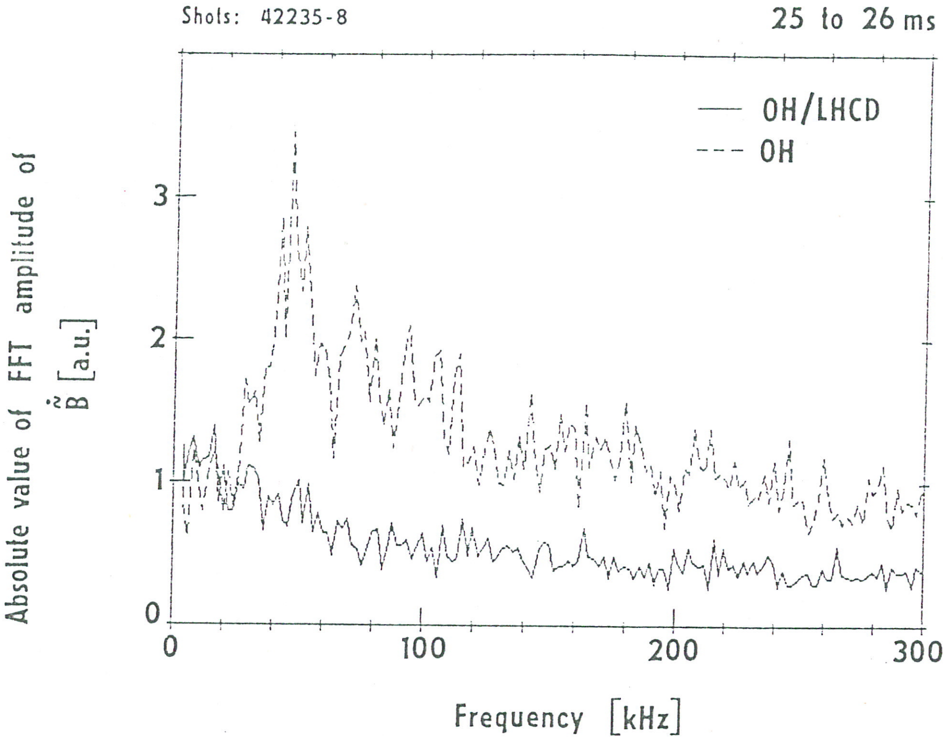

Fig.6 Fast fourier transform of the probe signals.

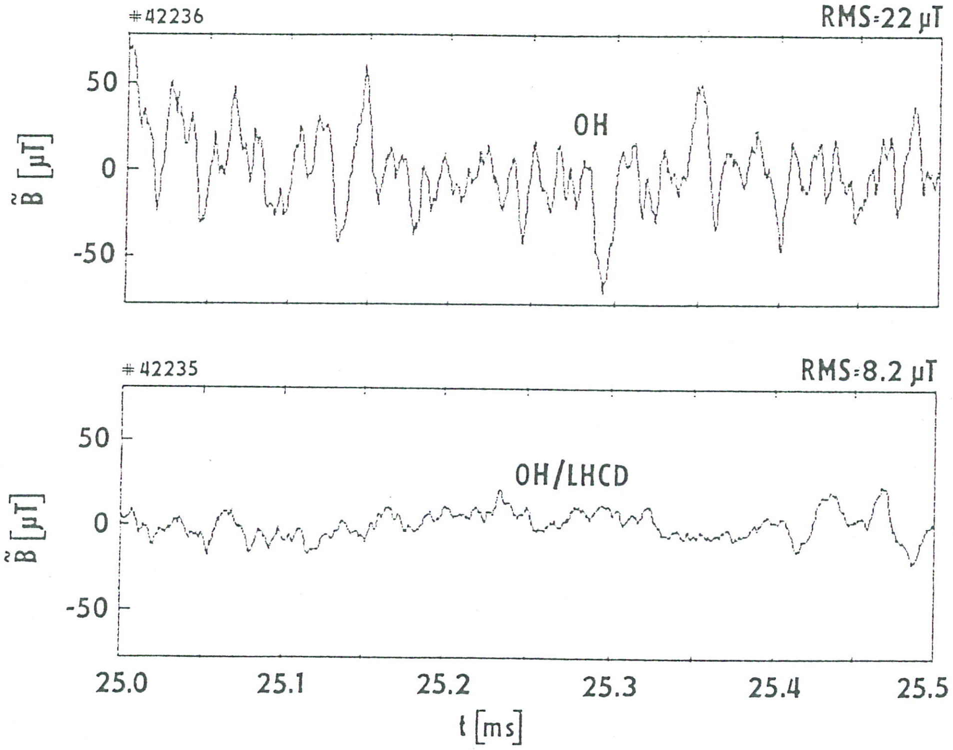

Fig.7 Fluctuating part of poloidal magnetic field calculating from probe signals in Fig.3. The calculated RMS values represent 6.5x10-4 resp. 2.5x10-4 of the total poloidal magnetic field.

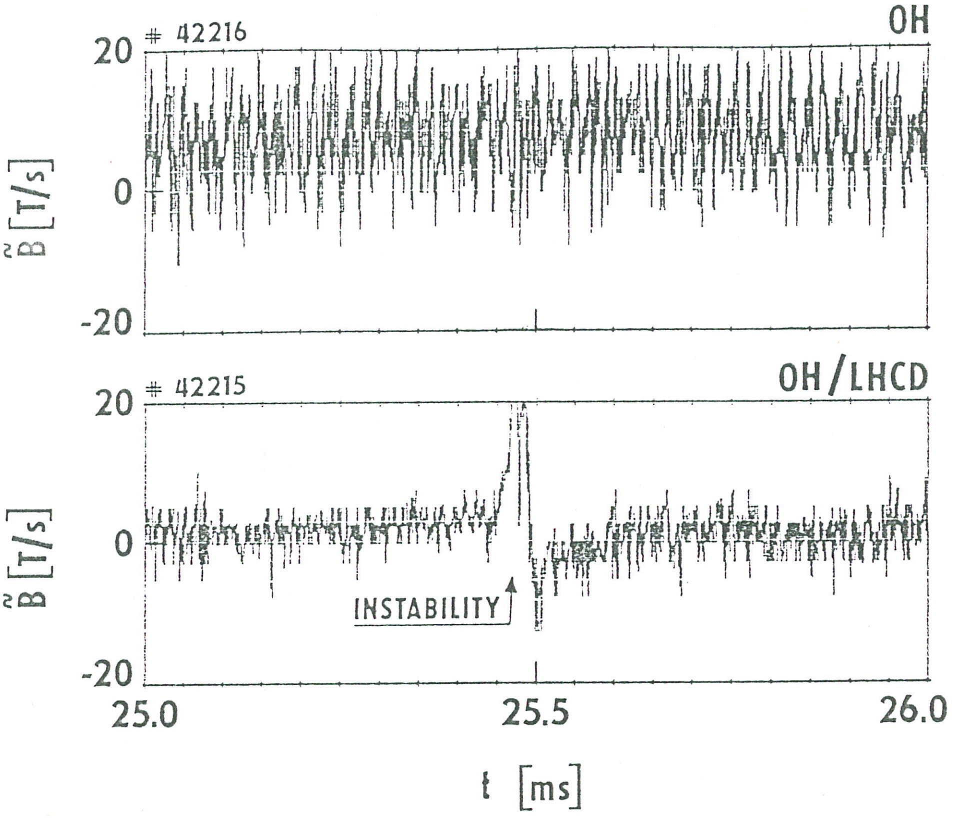

Fig.4 Effect of first Parail-Pogutse instability on magnetic fluctuations.

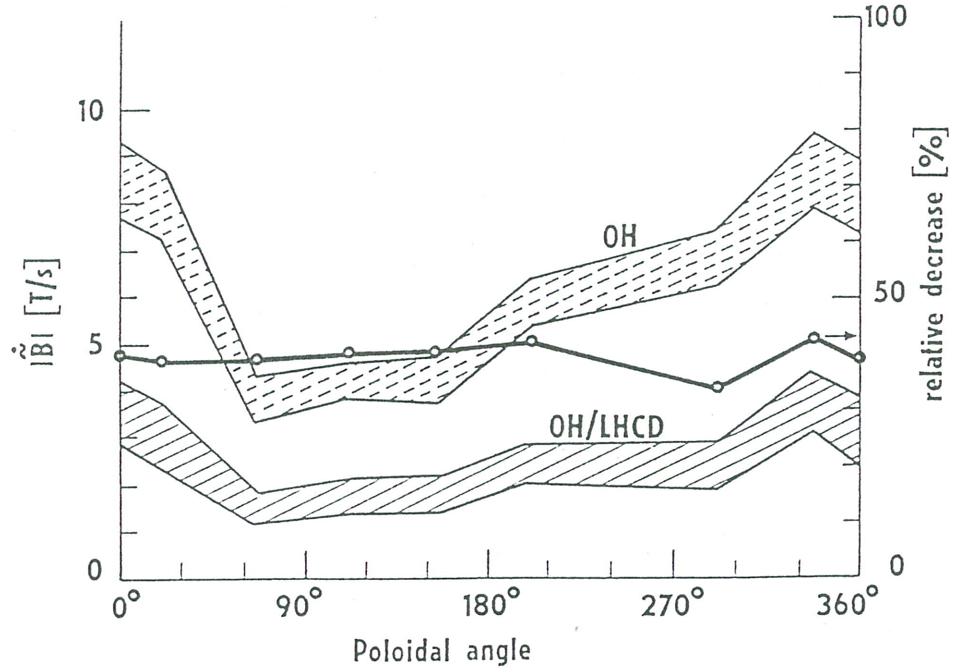

Fig.5 Dependence of level of magnetic fluctuation on poloidal angle. The results are taken from shots in Fig.3 by averaging fluctuation level from 25 to 26 ms for probes 2, 4, 6, 8, 10, 14 and 16 (angles 0 and 90 deg. correspond to probes 1 and 5 respectively).

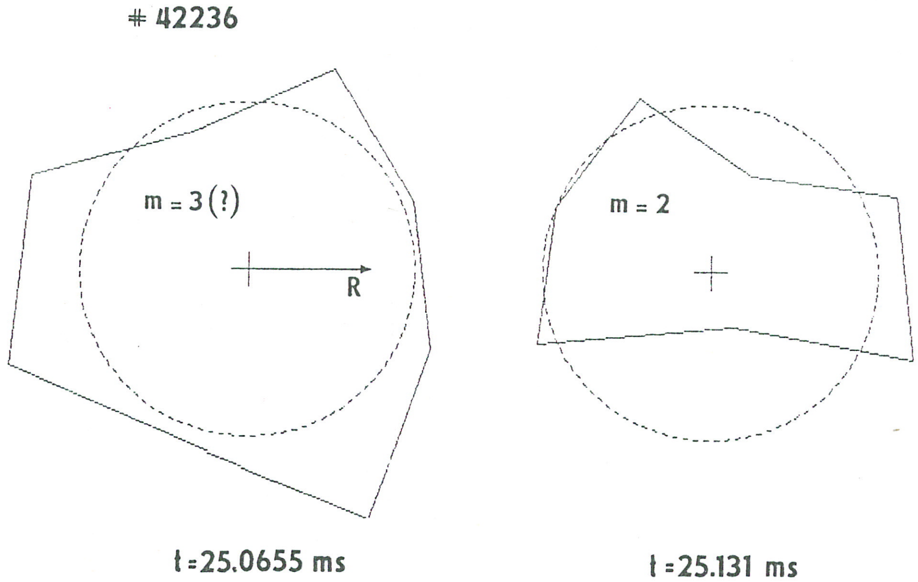

Fig.8. Poloidal diagrams of the fluctuating magnetic field signals at two instants (for whole temporal evolution of magnetic field at probe 14 see Fig.7-OH).

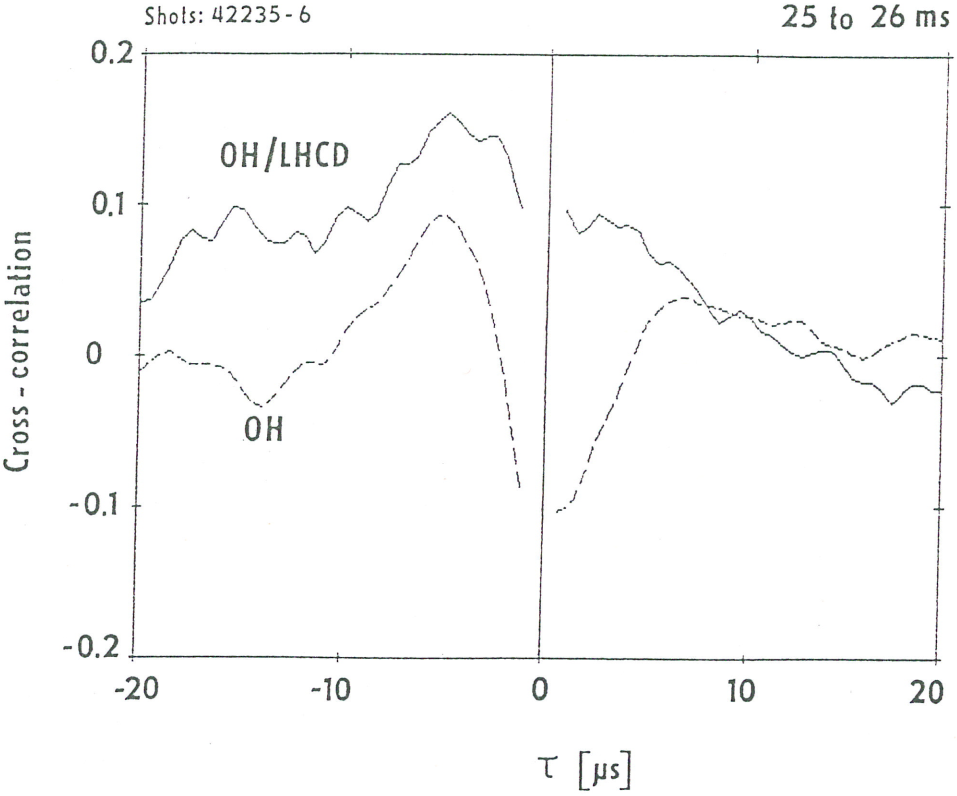

Fig.9. Cross-correlation between coil signals.
A curve is an average of cross-correlations of 6 pairs of neighbouring coils from the set as in Fig.5.