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Edge Fluctuations, Disruption and Limiter Biasing in the CT-6B Tokamak

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Abstract

The MHD and electrostatic fluctuations have been investigated in the plasma boundary region of the CT-6B tokamak using an array of Mirnov coils and a movable isolated biasing limiter. In the normal and limiter biased discharges, formation of a disruption studied. The results shown that by changing the time of applying positive bias voltages the sudden disruption may be controlled. In addition, it is found that there is a coherency between fluctuation frequencies of poloidal magnetic field oscillations, plasma potential fluctuation and H_α emission fluctuation and suppression of fluctuations at the core and edge of plasma.
Biasing operation at low plasma current <15 kA with hydrogen plasmas heated ohmically, shows different behavior with respect to higher plasma currents ~30 kA regime. Also, by applying positive bias voltage on plasma is seems effect on MHD mode behavior.

1. Introduction

Plasma turbulence is considered one of the main causes of anomalous transport in toroidal magnetic confinement devices. Edge biasing experiments have been found to be important in modifying edge turbulence and transport, but the mechanism of biasing penetration in edge fluctuations and its levels are different with respect to devices operation. The magnetic and floating potential fluctuations and their levels have been shown as addresses of the edge turbulence and particle transport [1-10]. Also there are links between the transports in the edge and disruption triggering so an experimental study for edge fluctuation during normal and limiter biasing regimes is carried out. During biasing regime, the effects of a positive limiter biasing on the plasma floating potential, poloidal magnetic field and H_α emission fluctuations are also examined. A comparison between behaviors of MHD oscillation lead to disruption by changing bias application time has been done. In the sections to follow a description of the experiment, its findings and conclusion are presented.

2. Description of the experiment

The experiments were conducted on the ohmically heated iron core CT-6B tokamak, with a major radius R=0.45m and a minor radius a=0.125m defined by a fixed four-block poloidal limiter. The vacuum chamber was a stainless steel welding structure with two toroidal breaks and a minor radius *b*=0.15m. The biasing experiments were performed under a pulsed biasing regime, usually at plateau regime, and remained active until the end of discharge. The biased voltage was restricted to -125V$\leq V_{bias} \leq$220V. The array of Mirnov coils and H_α spectrometer detectors were mounted at toroidally 75° and 90°, respectively, from the limiter-biasing device. The conditions of the experiment were as follows: The toroidal magnetic field B_t=6.5-7.5kG, plasma current I_p=30kA, chord-averaged electron density n_e=0.5-1.5x10^{19}m^{-3} in hydrogen and the plasma discharge duration ~30ms. The data were digitized at 6.4μsec resolution using a multi-channel data acquisition system.

3. Results and discussion

The biasing experiments were performed under a pulsed biasing regime, usually at the plateau regime and to the end of discharge. In all experiments, subsequent to the application of a positive bias, a decrease followed by an increase in the frequency of magnetic field fluctuations was observed (see Ref.3). The result of this experiment for positive bias is different from other tokamaks. For example, the MHD behavior of *negative* bias in the ISTTOK[11] tokamak is similar to *positive* bias in the CT-6B tokamak. The plasma current in CT-6B during high plasma current regime is some times higher than in the ISTTOK one. In the CT-6B tokamak during low plasma current regime <15 kA, and high plasma current >30kA it can be seen that after a positive bias voltage in the low regime the H_α emission intensity first decreases and then onsets to increase (see Ref.14). In the high plasma current the H_α line emission after a positive bias first increases and then begins to decrease. Of course the clear and sinusoidal MHD oscillation ca be seen in the high plasma current. In the CT-6B Tokamak the FFT analysis of the Mirnov coil oscillations positioned at equatorial outer-side midplane, the floating potential fluctuation, V_f, at *r*/*a*=1 and line emission H_α intensity at *r*/*a*=0.8 investigated before and 3msec after biasing (V_{bias}= +150V) as shown in fig.1. It can be seen that there is a clear coherency between signals at the frequency of about 25kHz.

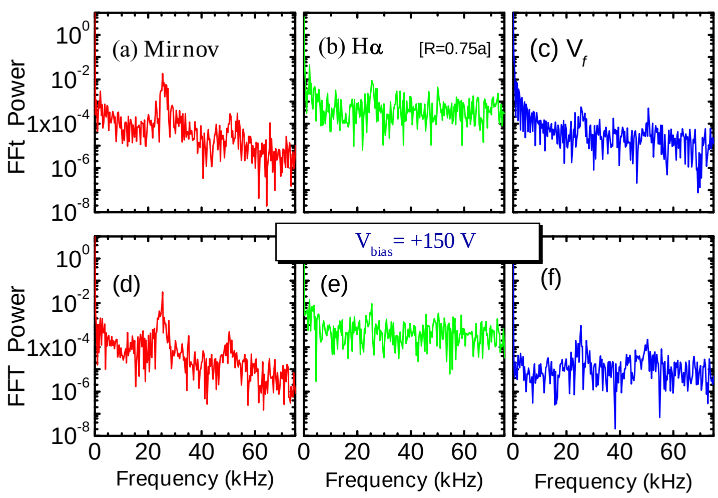

Fig. 1. The coherency between Magnetic fluctuation, floating potential and line Ha intensity emission.

At many shots the H_α intensity fluctuations in the area of q=2-3 correlates more with Mirnov signal fluctuations, which are not shown here. When the limiter is biased, the plasma potential floats to a value close to the bias potential. Following the comparison of the bias potential fluctuations with Langmuir probe results at the same position, it is found that they behave similarly. In the figs.1(c) and 1(f), it can be seen that the low frequency floating potential fluctuations level <20kHz decreases after a positive bias near the limiter. This behavior is similar to ADITYA[15], KT-5C[12], AFT Torsatron[16] and Thorello[13], so the transport seems be inward. On the other hand, the floating potential fluctuation in TEXTOR[17] and STOR-M[18], through positive biasing, increases near the limiter when outward flow decreases. The difference between results can be due to the conditions of device operation. Therefore, determining the penetration value of magnetic fluctuations and floating potential fluctuations levels on the transport and turbulence requires further measurements of plasma parameters.

The basic physics mechanism that is responsible for mode locking is the toroidal rotation braking (dissipation) effect of error fields in slowing and ultimately stopping the rotation of *m/n* MHD modes at the $q = m/n$ rational surface. Once such a locked mode develops, the mode amplitude grows and the resulting high amplitude saturated mode can degrade confinement quality or result in subsequent or immediate disruption. Fig.2 shows an effect of external electric field on MHD behavior of plasma. It can be seen that after applying bias voltage during formation of MHD modes in the current ramp up it make long pulse plasma and when the biasing voltage is at the current plateau when a q=2 mode is forming it grows the amplitude of mode oscillation follows by a disruption.

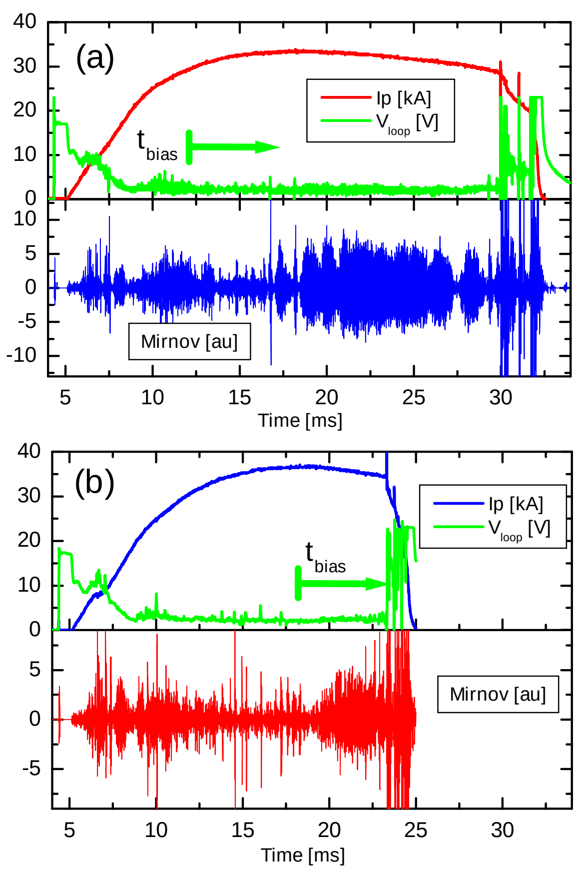

Fig. 2. Two biasing regime in biasing time application, a) ramp up current (t_{bias}=12ms and b) plateau area of plasma current t_{bias}=18ms with same bias voltage +100 Volts.

4. Conclusion

Behavior of plasma fluctuations by a positive limiter biasing experiment were studied on the CT-6B Tokamak using an array of external Mirnov coils and an isolated limiter, to get magnetic and potential fluctuations, and using an optical system to measure the line emission of H_α intensity. Positive biasing reduces MHD oscillations frequency, at first, but after a short delay time the frequency of oscillations increases, which seems to be as a result of a difference in the time scales of the response of magnetic field, electrostatic fluctuation and H_α emission to the bias voltage. During the biasing regime, it was found that the magnetic and electrostatic fluctuations in the CT-6B tokamak have a close coherency with H_α line emission fluctuations. The results for magnetic oscillation frequency and floating potential fluctuations during positive biasing are different from other devices, which may be due to the conditions of device operation so that for two regimes plasma current the behavior is different. The external electric field as positive limiter biasing can affect on MHD mode behavior to encountering a disruption.

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