

Study of Poloidal Rotation Velocity in the Tokamak Plasmas

P. Khorshid¹, L. Wang², M. Ghoranneviss³, X.Z. Yang², C.H. Feng²

¹ *Department of Physics, Islamic Azad University, Mashhad, Iran*

² *Institute of Physics, Chinese Academy of Sciences, Beijing, China*

³ *Plasma Physics Research Centre, Islamic Azad University, Tehran, Iran*

Introduction

As experiments indicate, the transition to the tokamak H-mode from the L-mode, which is connected to a significant change in confinement characteristics, has a causal relationship to the sudden onset of a toroidal and/or poloidal rotation and the rise of a radial electric field [1-3]. Both types of rotation, although driven and damped by different mechanisms, are somehow interrelated and serve to suppress magnetic and density fluctuations in the edge. The neoclassical theory of particle transport in tokamak has predicted that the poloidal rotation velocity of impurity ions would be quite different from that of main ions. [4] In the H-mode operation of DIII-D device, the poloidal rotation of main ions in edge region was measured in helium plasma, and was found to be in the ion diamagnetic direction, opposite to that of impurity ions. [5]

In the CT-6B tokamak, the Doppler shift of impurity spectral lines has been measured with optical diagnostics and was used to compute the poloidal rotation velocity of plasma. [6-8] The results showed that the rotation velocity was in the electron diamagnetic drift direction in the plasma core, and was in the ion diamagnetic drift direction in the edge region. In the CT-6B, as a small device with a lower plasma temperature, atoms can penetrate into the plasma core. In order to measure the poloidal rotation velocity distribution of neutrals in the whole plasma region, the measurement system has been improved, including a newly designed fine-adjusted light reflection system. In the present research, an experimental study for plasma rotation based on mode structure via Mirnov oscillation is carried out. In addition, during biasing application [9], the effects of a positive limiter biasing on the poloidal rotations are also examined. In the sections to follow a description of the experiment, its findings and conclusion are presented.

Description of the experiment

The experiments were conducted on the ohmically heated iron core CT-6B tokamak, with a major radius $R=0.45\text{m}$ and a minor radius $a=0.125\text{m}$ 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 $b=0.15\text{m}$. An array of twelve Mirnov coils is used for measuring the poloidal magnetic field oscillations and a segment poloidal limiter made of thin molybdenum plate, 8cm high and 2cm wide, electrically isolated with the chamber positioned at $r=0.125\text{m}$ on the outer side of the equatorial midplane of the plasma, was employed as the biasing limiter, where r is the minor radius. Fig.1 shows the detailed time evolution of poloidal variations of poloidal amplitude dependence of magnetic field perturbation signals at 13.7msec; the samples are separated by 6.4 μsec intervals. So that is seen, rotation of mode $m=3$ is clear, the inside of torus with toroidal effects, the shape of plots are unsymmetrical so that, the number of mode inner side is more than outer side of machine. Fig.2 shows the phase data from Mirnov coils array located in poloidal angle; it is seen that there is a $2 < m < 3$ mode.

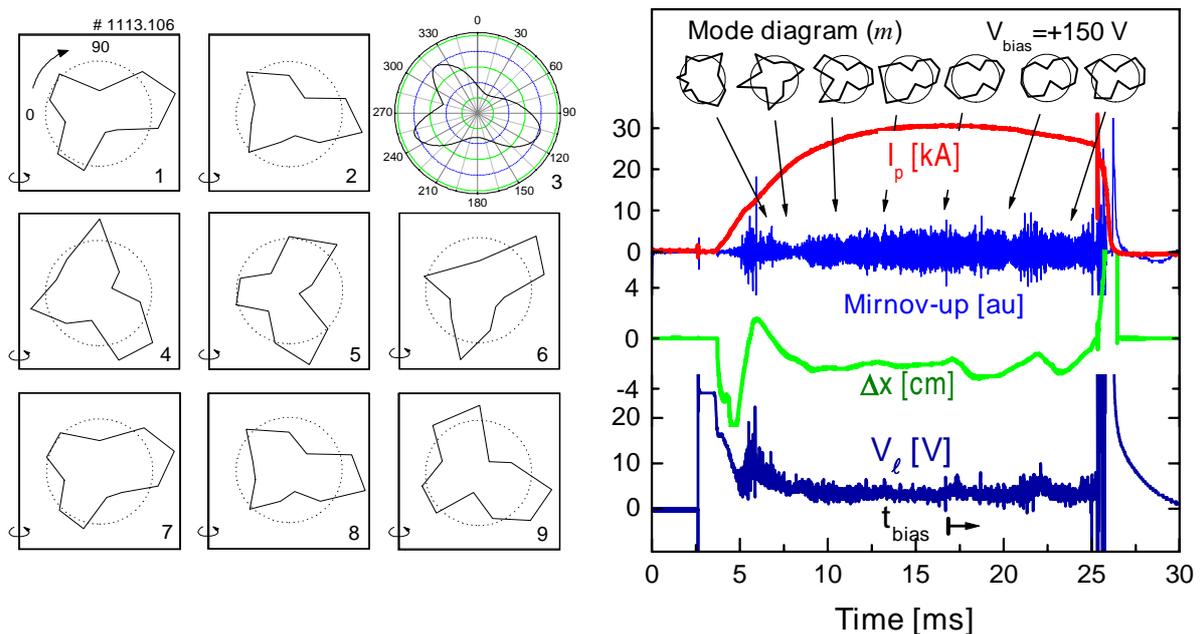
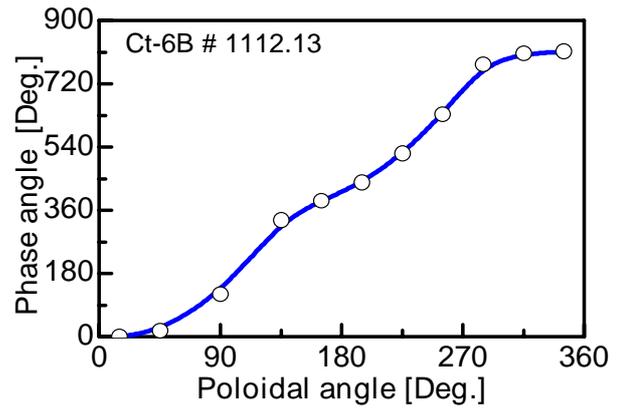


FIG.1. (left) Time evolution of poloidal variations of the amplitude of magnetic field perturbation at 13.7msec, the samples are separated by 6.4 μsec intervals. The spatial variations of mode number on the inner side of the Tokamak because of toroidal effects are more than outer side. A circle arrow in plots indicates the location of the inner side of the machine. (right) The time evolution of plasma parameters.

FIG.2. Phase data from Mirnov coils array located in poloidal angle shut No. 1112.13.



Since the MHD behavior or magnetic fluctuations is caused by rotation of magnetic islands, then these phase of oscillation indicates a kind of island, internal island and external island so that direction of these islands sometimes are same. A calculation from polar mode diagram technique, Mach probe and H_{α} Doppler shift spectroscopy have used for measuring the plasma rotation velocity for mode $m=2$ and mode with $m=3$ for $r=7.5$ cm and $r=9.1$ cm magnetic island location at CT-6B tokamak as shown in fig.3.

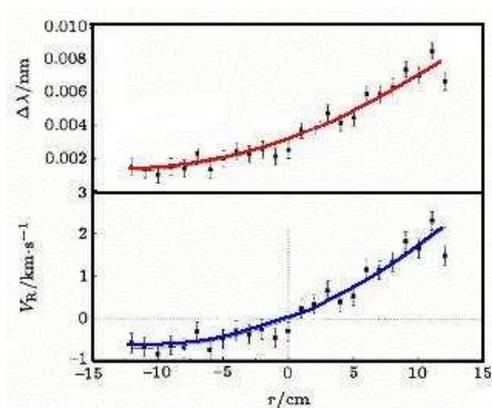
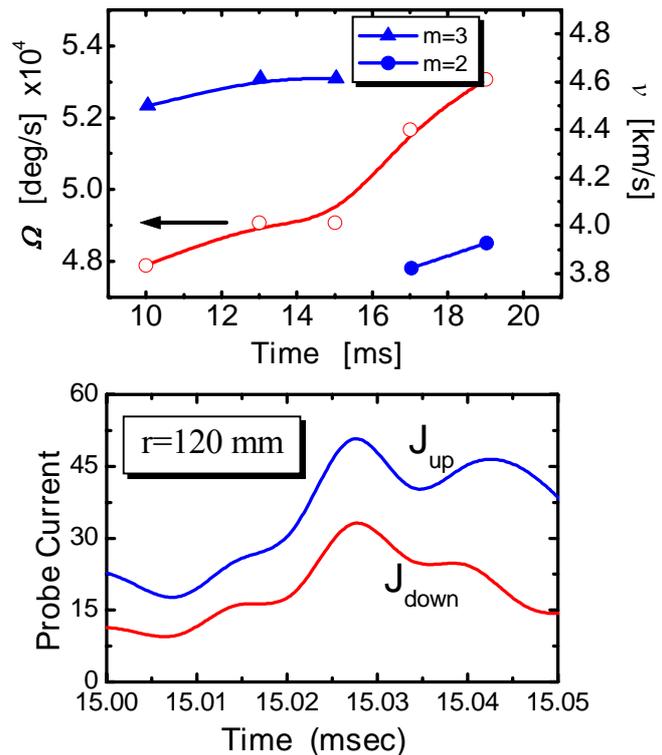
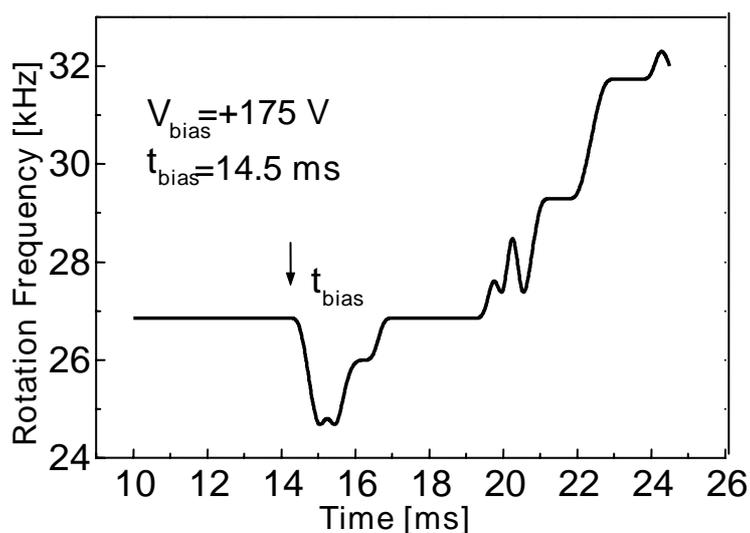


Fig.3. Plasma rotation velocity for mode $m=2$ and mode with $m=3$ for $r=7.5$ cm and $r=9.1$ cm magnetic island location respectively. The open circle indicated rotation measured via Mach probe and H_{α} emission.



During positive limiter biasing the frequency of poloidal rotation first decreases and then after a delay time about 2-3 ms it increases with a faster speed as shown in fig.4. In HT-6M [10], the results show that v_{θ} increases just after transition for $r/a < 1$ so that the first 2 ms of its results is different from CT-6B [9].

FIG.4. The time evolution of plasma rotation frequency in the CT-6B after applying positive bias voltage.



In conclusion, in the edge plasma of the CT-6B tokamak the poloidal rotation velocity based on Mirnov oscillations has been investigated. Polar mode diagram technique has been used to measuring the poloidal rotation velocity for mode $m=2$ and mode $m=3$ located at $r=8.0\text{cm}$ and $r=9.1\text{cm}$ respectively. The results show that inside of torus with toroidal field effects, the shapes of plots are unsymmetrical, so that, the number of mode inner-side is more than outer side of machine. The results have been compared with measurements of poloidal rotation velocity via Mach probe and Doppler shift of H_{α} line spectroscopy. The results of experiment show that magnetic islands have a velocity close to bulk of plasma column rotation. Also, during positive limiter bias application the poloidal magnetic field oscillations first decreased and then after a delay time it increased with a faster speed.

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