Contribution ID: **526** Type: **Poster**

Investigation of Co-Current Rotation at Plasma Edge in the TCABR

Friday 17 October 2014 08:30 (4 hours)

Poloidal and toroidal plasma rotation play an important role on particle and energy confinement and on the stabilization of magnetohydrodynamic instabilities, depending on the rotation intensity.
In the TCABR tokamak, the intrinsic toroidal rotation in ohmic discharges is normally sheared, with counter-current in the core and co-current rotation at plasma edge.
The origin of co-current rotation may be related to a radial friction force between neutral particles and ions/electrons during gas injection. This radial force in the presence of a poloidal component of the magnetic field accelerates plasma in the toroidal direction. If the speed of neutral particles is much larger than the diffusion velocity of ions/electrons, the friction force is in radial direction (outward), which produces co-current rotation.
In turbulent plasmas, electrons and ions can diffuse in radial direction with equal velocity due the ambipolar diffusion. In the TCABR tokamak the velocity of neutral particles is of order of 10^3 m/s, while the ions and electrons diffusion velocity is about 10 m/s, which produces an outward radial friction force. We suspect that in small machines, where the electron temperature at plasma edge is of order of 10 eV, neutral gas can penetrate into the plasma column for a short time before being ionized. These neutral particles will produce co-rotation. A rough estimate for ionization time at the plasma edge in TCABR is 10^-4 s, for electron temperature and density around 10eV and 10^18 m^-3, respectively. For this characteristic ionization time, a neutral particle can penetrate 10 cm inside the plasma.
To investigate this mechanism, we are carrying out an experimental program for measuring the toroidal rotation at plasma edge for different poloidal positions of gas injection, i.e., top, outboard, and inboard, at the same poloidal cross-section and always in the radial direction. We have observed increase of co-current rotation at radial position r/a=0.94 during gas injection at all poloidal positions.
The next phase of the experimental campaign will focus on gas injection in the toroidal and poloidal directions. In the paper we will present a comprehensive report on the experimental results and will discuss a model to describe the correlation of intrinsic co-current rotation at plasma edge with the position of gas injection.

Country or International Organisation

Brazil

Paper Number

EX/P7-44

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Session Classification: Poster 7