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Magnetic island formation in locked-like mode in helical plasmas

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We report the discovery of the magnetic island formed in the locked-like mode in helical plasma. New analysis and observation techniques applied to the ECE signal and poloidal flow in LHD experiments show the following results. (i) The magnetic island structure is present. This indicates that the resistive interchange mode can induce the rotating magnetic island in the locking phase. (ii) The rotation speed of the island is not uniform in space. The toroidal structure of the island changes in the locking-phase, and the deformation increases till the mode is locked. These results are quite meaningful to understand the locked mode instability affecting the confinement.

The locked mode is well understood as the tearing mode in some tokamaks. In the LHD, a non-rotating m/n=1/1 mode has been observed and it is identified as the resistive interchange mode. A minor collapse was observed with the damping of the magnetic fluctuation frequency and the lock of the mode. This is called "locked-like"mode. In the analogy of the tokamak locked tearing mode, the magnetic island existence has been implicated.

The clear indication of the magnetic island is obtained by ECE radiometer just before the locked phase that the strong m/n=1/1 component of the radial magnetic field rises rapidly. The rotating m/n=1/1 mode component included in the fluctuation amplitude and the phase difference of ECE intensity can be extracted. The odd radial structure and the flattened Te profile clearly appear. It is also found that the inverse position is mostly the same as the iota/2pi=1 surface.

The value of poloidal velocity Vp measured by toroidally-correlated microwave Doppler reflectometers is changed back and forth from around -4 to 0 km/s during the locking phase. It should be noted that Vp ~0 means that the O-point of the rotating magnetic island comes to the observation region. The staying time of the O-point of rotating island in the observation region is found to be different in the different toroidal locations. It suggests that the island structure is toroidally non-uniform. Also, the phase difference between two Vp measurements is changed in time. It is possible to explain as the distortion of the rotation structure that is the twisting rotating island structure disobeys the equilibrium magnetic structure. This distortion would lead to the damping of the rotation velocity.

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