Slow Formation of Spherical Tokamak by ECH on LATE

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The main objective of LATE (Low Aspect ratio Torus Experiment) is to demonstrate start-up and formation of Spherical Tokamak by ECH/ECCD alone without a central Ohmic solenoid. By injecting a 2.45 GHz microwave pulse up to 30 kW for four seconds, a plasma current has been initiated and ramped up over 6 kA with a slow ramp of the external vertical field for the equilibrium of the plasma loop, as shown in Fig.1.

Firstly, the steady external vertical field (Bv) is applied and the hydrogen gas is introduced. Microwaves from three magnetrons are injected from outboard side through three radial ports at oblique angles with the linearly polarized electric field on the equatorial plane. An initial plasma is instantly produced at the fundamental EC resonance layer (R = 13.7 cm), and quickly expands into the low field side. Then the plasma current is generated and rapidly increased up to 1.2 kA spontaneously, and the closed flux surface is formed under this steady Bv field (Bv = 12 G). The Bv decay index is set to be very low, which allows the production of vertically elongated plasmas. The plasma current ramps up slowly by increasing the total microwave power and the Bv field in order to keep the equilibrium of the plasma loop. Finally, the plasma current reaches Ip = 6.25 kA at Bv = 70 G and sustained steady for 0.5 s until the microwave power is terminated. This value of the plasma current amounts to above 10 % of the toroidal coil current (60 kAT) and the magnetic field line on the last closed flux surface reveals the characteristic of the ST equilibria as shown in Fig.2.

The magnetic analysis shows that the last closed surface has an aspect ratio of A ~ 1.4 and an elongation of κ ~ 1.5 (Ro = 21 cm, a = 15 cm, b = 22.3 cm) at the final stage of discharge, as shown in Fig.3. The shape of the last closed flux surface as well as the center of the plasma current essentially does not change throughout the discharge, and this current center is located near the second harmonic EC resonance layer at R = 27.4 cm. The line averaged electron density along the vertical chord at R = 27 cm increases toward the final stage, and reaches about twice the plasma cutoff density. These results suggest that the second harmonic ECH by the mode-converted electron Bernstein wave is responsible for the heating and current drive.

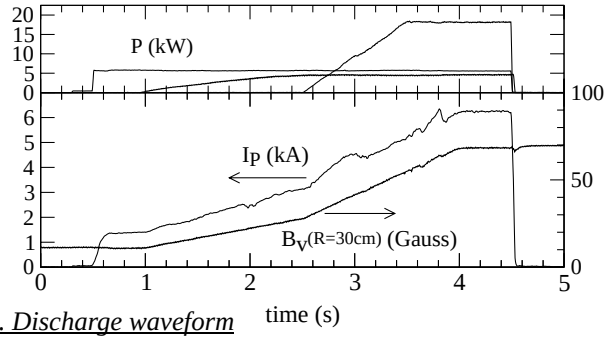

Fig1. Discharge waveform

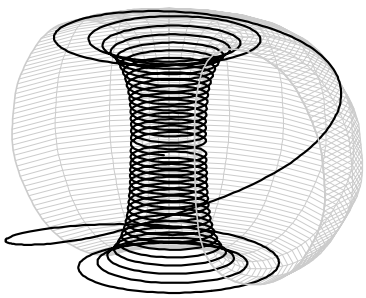

Fig.2 Magnetic field line on the last closed flux surface at t=4.3s

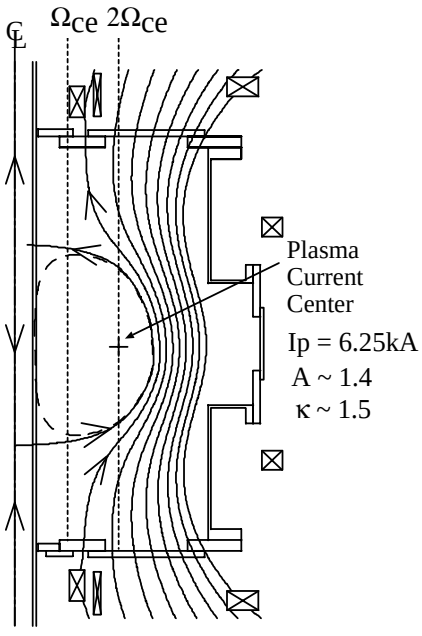

Fig.3 Poloidal flux contours at t=4.3s