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EX/P6-18: Noninductive Formation of Spherical Tokamak at 7 Times the Plasma Cutoff Density by Electron Bernstein Wave Heating and Current Drive on LATE

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We report on an experiment of spherical tokamak formation by electron Bernstein (EB) waves in the Low Aspect ratio Torus Experiment device, in which the current reaches 10 kA and the density reaches 7 times the plasma cutoff density. Thus an extremely overdense torus plasma has been for the first time produced and maintained solely by EB waves. In the LATE device it was shown that EB waves can rapidly ramp up the plasma current as fast as 260 kA/s, comparable to the lower hybrid ramp-up rate. Another important capability of EB waves for production and heating of extremely overdense torus plasma has been shown in this paper.
The microwaves at 2.45 GHz from four magnetrons are injected from midplane four launchers with an oblique angle in the form of O-mode. When a microwave power of Pinj = 10 kW is injected under a weak vertical field of Bv = 18 G, a plasma current is initiated and increases up to 2 kA, resulting in the formation of closed flux surfaces. Next, the plasma current ramps up with ramps of the microwave power and Bv, and finally reaches 9.3 kA, after which the plasma is kept steady by Pinj = 40 kW under Bv = 100 G for 40 ms until the end of microwave pulse (The current reaches 11 kA when Pinj = 58 kW and Bv = 120 G.). The forward X-ray develops both in energy range and photon counts as Ip increases, indicating that the current is carried by EB-wave driven fast electron tail. The four chords measurement of line integrated density shows that the density reaches extremely overdense regime in the final steady phase. The final line averaged density reaches n_e = 5.2 x 10^17 m^-3, that is 7 times the plasma cutoff density.
The upper hybrid resonance (UHR) layer is estimated to lie to higher field side of the 2nd ECR layer. Then EB waves mode converted from the incident electromagnetic waves at the UHR layer propagate in their first propagation band toward the fundamental ECR layer and may heat the bulk electrons as well as the fast electrons at the plasma core. Extreme ultraviolet emission signals from the vertical chords crossing the ECR layer on midplane show a large increase towards the final steady phase. In addition, impurity line radiations at higher excitation energies such as CV (304 eV) and OV (72 eV) appear and strongly increase toward the final stage, suggesting that the electron temperature also increase.

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