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EX/P6-16: Electron Bernstein Wave Heating and Electron Cyclotron Current Drive by Use of Upgraded ECH System in LHD

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In LHD, electron Bernstein wave (EBW) heating was successfully demonstrated by two ways of mode conversion to EBWs from injected EC-waves, by so-called slow-XB and OXB techniques. To realize the excitation of EBWs by the slow-XB technique, EC-waves in X-mode polarization should be injected to plasmas from high magnetic field side (HFS). In LHD, newly installed inner-vessel mirror close to a helical coil is used for the HFS injection. Evident increases in Te at the plasma core region and Wp were caused by the HFS injection with 0.18 s pulse width to a plasma with ne(0) of 24x10ˆ19 mˆ-3, that is, 3.3 times higher than the plasma cut-off density for O-mode waves, and 1.6 times higher than the left-hand cut-off density of 14.7x10ˆ19 mˆ-3 for slow-X-mode waves. Thus, the heating effects especially the increase in Te at the plasma core region should be attributed to the mode-converted EBWs, not to the X- or O-mode waves.

For excitation of EBWs by the OXB technique, O-mode waves should be injected from the low magnetic filed side toward the so-called "mode conversion window". Two pulses of 77 GHz, 1.05 MW EC-wave (0.1 s pulse width each with a 0.1 s interval) in O-mode polarization were injected to an NB-sustained plasma, aiming at the mode conversion window calculated in advance. With both of the two ECH pulses, increases in Wp and mitigations of decreasing trend in Te measured with ECE are recognized. The line average electron density continuously increased during the ECH pulse injection. At the start timing of the 1st pulse, ne(0) was equal to the O-mode cut-off density, 7.35x10ˆ19 mˆ-3, and ne(0) gradually increased to 7.7x10ˆ19 mˆ-3 at the end of the 2nd pulse. The heating efficiency Pabs/Pech is evaluated as ˜15%.

Using the high-power, long-pulse 77 GHz ECH system, 2nd harmonic on-axis ECCD experiments with 775 kW injection power and the line average electron density of 0.3x10ˆ19 mˆ-3 were conducted. At optimum beam directions, maximum EC-driven currents up to 40 kA in both the co- and counter-ECCD directions were achieved. Also, recent experiment indicated that ECCD could affect the formation of an electron internal transport barrier (e-ITB). The powerful ECCD is expected to be an effective tool to control the MHD activity and the formation of e-ITB through the modification of current and rotational transform profiles.

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