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Electron Cyclotron Current Drive in DEMO Plasmas

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Electron cyclotron (EC) waves offer several advantages as a heating scheme in a tokamak fusion reactor, both from the technological (the launchers require small slots in the blanket; the first tritium barrier can be incorporated into the vacuum vessel) and the physical (easy wave-plasma coupling; localized absorption) point of view. The most crucial applications of EC waves in a reactor are the sustainment of part of the plasma current and the stabilization of MHD instabilities like the neoclassical tearing mode (NTM). Here we focus on some recent theoretical advances and simulation results concerning the application of EC waves in DEMO plasmas.

When the electron temperature exceeds ca. 30 keV, the current drive efficiency is found to saturate [1], mainly due to parasitic absorption from the next cyclotron harmonic, in agreement with previous studies [2,3]. This problem can be mitigated by shifting the injection position towards the high-field side, e.g. to the top of the vacuum vessel. For temperatures below 30 keV, the maximum current drive is achieved as a balance between the need of heating suprathermal electrons and that of sufficient absorption [2]. A fast tool (HARE) to evaluate the maximum current drive has been developed on this basis [4]. The injection of extraordinary-mode waves at the fundamental harmonic for current drive in the outer plasma is discussed. For NTM stabilization, the situation is different, since the need for high current-drive efficiency, which is characterized by broad profiles, competes with the need for good localization. Simple criteria for NTM stabilization [5,6] provide a guidance for the determination of the optimum current drive profiles (i.e. those corresponding to NTM suppression at minimum injected power), as previously done for ITER [7]. The broadening of the absorption profiles due to beam scattering by density fluctuations becomes crucial in large machines [8] and needs to be assessed.

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