Electron Cyclotron Heating and Current Drive in ITER*

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Abstract

Electron cyclotron (EC) power has technological and physics advantages for heating and current drive (CD) in a tokamak reactor, and advances in source development make it credible for applications in the International Thermonuclear Experimental Reactor (ITER). Strong single pass absorption makes heating to ignition in ITER particularly simple. At densities to $3.6 \cdot 10^{20}$ m^{-3}, with Ohmic temperatures and wave frequency 170 GHz, heating in the plasma core is readily obtained. For outside launch of ordinary mode (O–mode) near the fundamental electron cyclotron frequency, the optimized EC current drive (ECCD) efficiency ($\langle n \rangle IR/P$) shows a linear temperature scaling at temperatures up to ~ 15 keV. For temperatures above 30 keV, the efficiency saturates at approximately $0.3 \cdot 10^{20}$ A/(m^{2}W) for a frequency of 220 GHz in an ITER target plasma with toroidal field of 6 T, due primarily to harmonic overlap [G.R. Smith *et al.*, Phys. Fluids **30** 3633 (1987)] and to a lesser extent due to limitations arising from relativistic effects [N.J. Fisch, Phys. Rev. A **24** 3245 (1981)].

The same efficiency can also be obtained at 170 GHz for the same plasma equilibrium and q-profile except that the magnetic field is reduced to $(170/220) \times 6$ T $= 4.6$ T. The ECCD efficiencies are obtained with the comprehensive 3D, bounce-averaged Fokker-Planck codes CQL3D [R.W. Harvey and M.G. McCoy, Proc. IAEA TCM/ Advances in Simulation and Modeling in Thermonuclear Plasmas 1992, Montreal] and BANDIT3D [M.R. O'Brien, M. Cox, C.D. Warrick, and F.S. Zaitsev, *ibid.*].

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