Current Drive by Electron Bernstein Waves

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The steady-state confinement of tokamak plasmas in a fusion reactor requires non-inductively driven toroidal currents. Radio frequency waves in the electron cyclotron (EC) range of frequencies can drive localized currents and are thus particularly attractive for control of the current profile. In overdense plasmas, where the electron plasma (EP) frequency is higher than the EC frequency, electron Bernstein waves (EBW) are an attractive alternative to conventional X- and O-modes for driving currents. EBWs are particularly interesting for the high-β regimes of spherical tori (ST) such as NSTX and MAST, where the EP frequency is many times the EC frequency so that heating and current drive (CD) by electromagnetic ECW is not possible.

Based on the properties of EBW propagation and damping [1], the current driven by EBWs is calculated using the Fokker-Planck code DKE [2]. This code solves the bounce-averaged drift kinetic equation with a quasilinear diffusion operator describing the wave-particle interaction. EBWCD differs significantly from ECCD. Unlike electromagnetic ECW the EBW wavelength is comparable to or shorter than the electron Larmor radius, and the parallel index of refraction can be greater than one. We describe details of our study of EBWCD in various plasma configurations. We find that EBWs can be used to drive current both in the core and near the edge of the plasma using, respectively, the Fisch-Boozer and the Ohkawa schemes. In addition, the CD efficiencies with EBWs are found to be significantly higher than with ECWs for comparable plasma parameters. The increase in efficiency is explained by the fact that the EBW power is deposited on electrons that are faster, and therefore less collisional, than the electrons heated by ECW.

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References

[1] A.K. Ram, J. Decker, and Y. Peysson, *J. Plasma Physics* **71**, 675 (2005);
See also A.K. Ram, *et al.* "Propagation and Damping of EBWs", this workshop.
[2] J. Decker and Y. Peysson, Euratom-CEA report EUR-CEAFC-1736 (2004)