Role of ECH and ECCD in High-Performance Steady-State Scenarios

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The ability to control the location and localization of energy and current deposition in fusion plasmas with electron cyclotron waves is unmatched by any other auxiliary heating and current drive method. The establishment of the physics basis of the wave propagation and absorption allows accurate prediction of the deposition given the launcher optics and the profiles of magnetic field, electron density, electron temperature, and impurity density. This, along with the development of the technology of high-power millimeter-wave sources and the means to transmit them to the plasma, has facilitated experiments in present-day fusion devices to demonstrate the utility of heating and current drive with electron cyclotron waves (ECH and ECCD, respectively). Successful application in these experiments has motivated the use of ECH and ECCD in key roles in ITER and proposals for use in power plants.

Three primary roles are envisioned for ECH or ECCD in burning plasmas. First, all burning plasma scenarios require some access conditions, whether it is merely heating the plasma to fusion-relevant conditions or generating specific profiles of the magnetic field necessary to access steady-state operation in a tokamak. Second, tokamak-based steady-state scenarios require efficient auxiliary current drive to sustain the magnetic configuration. Finally, control of the operating point of a burning plasma is essential. This role includes applications such as burn control, response to off-normal events, and active control of plasma instabilities.

Each of these roles will be discussed using examples from present-day tokamak and stellarator experiments. Prospects for application in ITER and fusion power plants will also be presented.

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