Modeling of electron cyclotron current drive applied for neoclassical tearing mode stabilization

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A consistent model of electron cyclotron current drive (ECCD) in the presence of a neoclassical tearing mode (NTM) is set up. The plasma equilibrium is perturbed by the NTM changing in particular the topology of the magnetic field: a region around the resonant surface is broken up into a helical set of closed magnetic surfaces known as the magnetic island, while outside this island the toroidal magnetic surfaces remain closed but are helically deformed. The wave beam propagation in this perturbed equilibrium is described by ray tracing. The power absorption and current drive are then calculated on the sets of closed magnetic surfaces both inside and outside the island. Because of the small volume of the surfaces near the O-point of the magnetic island, the EC power density near the O-point can become very large and exceed the threshold for the appearance of nonlinear effects. Flux surface averaged quasi-linear Fokker-Planck code calculations are performed to quantify these nonlinear effects. The modeling is done for locked islands and for rotating islands. In the case of a rotating magnetic island, the results show a large phase delay between the maximum in the driven current density on a particular magnetic surface and the phase during which this surface is heated. This is a consequence of the highly non-local character of the ECCD and it's dominant origin in the Fisch-Boozer current drive effect.

In the case of MHD modeling of NTMs, the EC driven current density is described by a closure relation. Based on the Fokker-Planck code calculations and the origin of the ECCD in the Fisch-Boozer effect a new closure relation for the EC driven current is derived. The predictions of this closure relation are shown to compare well with the full Fokker-Planck calculations.