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Multi-scale methods for waves and transport processes in fusion plasmas: the legacy of Grigory Pereverzev

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Modeling of Electron Cyclotron Current Drive applied for the suppression of magnetic islands in tokamaks

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Electron Cyclotron Current Drive (ECCD) is applied in high beta tokamak plasmas to suppress the magnetic islands created by the so-called Neoclassical Tearing Mode. We describe the various aspects encountered in the modeling of ECCD in a magnetic topology including a magnetic island. When the ideal topology in a tokamak of nested toroidal surfaces is broken-up by a magnetic perturbation with a single helicity, a new topology of closed magnetic surfaces is formed including a chain of magnetic islands around the surface where the safety factor is resonant with the helicity of the magnetic perturbation. In our modeling we start from the equilibrium of an ASDEX Upgrade discharge which featured a 3/2 NTM. By introducing a perturbation to the poloidal flux with a 3/2 helicity, a topology is created that exhibits a 3/2 magnetic island similar to the experiment. In this perturbed topology the propagation of the electron cyclotron wave beam is modeled with the help of ray-tracing. The results of the ray-tracing are used to build a quasi-linear diffusion coefficient which is averaged over the closed flux-surfaces of the perturbed equilibrium. This quasi-linear diffusion coefficient is used in a bounce-averaged Fokker-Planck code to model the kinetic plasma response to the absorption of a high power EC wave beam. A particular result of the balance between EC quasi-linear diffusion and collisions is the generation of an asymmetry in the electron distribution function, representing a net parallel current. We study the nonlinear modification of the EC current drive efficiency which is the result of the high EC power densities achieved near the O-point of the magnetic island, where the volume between flux-surfaces becomes very small.