Physically based modelling of EC pre-ionization and assisted breakdown under ITER-like constaints

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In order to reduce demand on the central solenoid for startup in ITER, radio frequency power in the electron cyclotron (EC) frequency range will be used for ionizing the neutral gas [1].

Features of EC power, confined to a nearly-Gaussian beam, cannot be incorporated in the usual framework of Townsend theory for the breakdown phase [2]. The approach taken in our studies on the breakdown phase by EC beams, consists of modelling the interaction of an ensemble of seed electrons, confined by a magnetic field, with a spatially localized Gaussian beam in the presence of a background electrostatic potential. The canonical Hamilton-Jacobi dynamical equations of motion are solved numerically to study the energization of seed electrons by the wave fields. In the spatial region away from the beam, the electron motion is affected only by the toroidal electric field. We consider multiple interactions with the EC beams and characterize the electron energization in terms of the width of the beam, the frequency and polarization of the waves, the beam power, the direction of propagation of the beam (launching inclination), and the initial energy of the electrons. We incorporate cross-section evaluations for electron impact ionization of the neutral gas as well as elastic collisions [3], so as to determine the rate at which the electron population increases as a function of beam parameters.

The aim of our studies is to determine the threshold needed for the generation of an electron avalanche and reduce the time to reach this threshold. The projection of our preliminary results for ITER-like parameters [4] predicts that prionization with EC increases the energization rate about 4 times, leading to an ionization ratio 1.5 times greater at the breakdown time. Furthermore we can reduce the power at about two thirds and achieve the same energization rate and ionization ratio as long as we adjust accordingly the beam inclination and width.

References

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