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Breakdown time estimation for EC-assisted start-up in tokamaks

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A numerical tool modelling the excitation and evolution of electron avalanche ionization in the breakdown phase of start-up in tokamaks is presented. We estimate the energization efficiency of the nonlinear interaction between spatially localized Gaussian EC-fields propagating in vacuum with an ensemble of seed electrons. This process is coupled with the acceleration of electrons due to the induced loop voltage along the vacuum vessel, as well as the impact ionization and elastic collision events that lead to the abrupt increase of electron density during the avalanche process. Special care is taken to incorporate the effect of the toroidal magnetic field in the collision statistics [1]. Several numerical experiments are performed for configurations relevant to existing tokamaks [2] as well as ITER [3], dealing with all alternative start-up initiation procedures (ECRH pre-ionization [4], ECRH-assisted [5] and ohmic [6]). A simple analytical auxiliary tool based on the dynamics of avalanche evolution is developed in order to estimate the breakdown time as a function of the RF-field parameters, the loop voltage and the prefill pressure of the neutral gas.

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