Dynamics of positrons during relativistic electron runaway

O. Embréus[1], K. Richards[1], G. Papp[2] L. Hesslow[1], M. Hoppe[1], T. Fülöp[1]

[1]*Department of Physics, Chalmers University of Technology, SE-41296 Göteborg , Sweden*

[2]*Max-Planck-Institute for Plasma Physics, D-85748 Garching, Germany*

Sufficiently strong electric fields in plasmas can accelerate charged particles to relativistic energies via the runaway mechanism. In this contribution we describe the dynamics of positrons that are created during a runaway avalanche, and calculate the fraction of created positrons that become runaway accelerated. We find a sensitive electric-field dependence that is unlike the electron runaway growth rate due to the fact that positrons are born anisotropically in the direction opposite to their direction of acceleration.

For runaway in systems larger than a pair-production mean-free path, we derive a threshold electric field above which the direct pair production in collisions will dominate the pair production due to photons produced in hard X-ray emission, which is traditionally the main positron producing mechanism. This pair-production threshold field is found to be of the order of tens of avalanche threshold fields.

We present analytical and numerical solutions of the positron kinetic equation with a strong constant electric field, illustrating similarities and differences between the runaway dynamics of positrons and electrons. The numerical study provides the rate coefficients of created positrons that become runaway accelerated or thermalized. These are used to estimate the amount of annihilation radiation that will be detected during tokamak runaway scenarios as a function of background parameters, which can be compared to the amount of hard X-rays near 511 keV emitted by the runaway electron population. We find that the signal-to-noise ratio becomes worse when the plasma charge increases, whereas the total photon count increases. This tradeoff can be important in scenario development for positron detection experiments, which may be useful for assessing the validity of present models for runaway acceleration during disruptions.