Positron Production Processes in Non-Maxwellian Fusion Plasmas

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The study investigates positron generation by runaway electrons in fusion plasmas with Lorentzian electron populations. Unlike the Maxwellian model, the Lorentzian approach accounts for suprathermal particles that strongly influence collisional processes. The kappa-dependent Coulomb logarithm decreases as the plasma departs from equilibrium, reducing the rate of high-energy positron production and modifying the runaway-electron energy distribution. Runaway-electron interactions are analyzed under modern tokamak conditions using exact and ultra-relativistic cross sections for electron–positron pair creation. The model incorporates realistic electron dynamics, including electric and magnetic field effects, trapping, and drift orbits. The kappa-dependent screening length determines the modified Coulomb logarithm, allowing simulation of various non-equilibrium states relevant to laboratory and astrophysical plasmas. Numerical results show that lower kappa values lead to smaller Coulomb logarithms and stronger anisotropy of runaway electrons along the magnetic field. Lorentzian plasmas exhibit more beam-like electron distributions with fewer ultra-relativistic particles, causing a decline in positron generation, especially at high energies. The positron momentum spectrum shifts toward lower energies with decreasing electron temperature and increasing kappa.