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ELECTRON INJECTION AT NONRELATIVISTIC SHOCKS OF YOUNG SUPERNOVA REMNANTS

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Particle pre-acceleration constitutes a central unresolved problem for diffusive shock acceleration process assumed to provide high-energy cosmic rays in astrophysical plasma environments. Here, we report on recent studies of electron injection at high Mach-number nonrelativistic perpendicular shocks with application to forward shocks of young supernova remnants. We use high-resolution large-scale two-dimensional fully kinetic particle-in-cell simulations that sample a representative portion of the turbulent shock front and account for time-dependent effects of the cyclic shock reformation. We discuss a nonlinear shock structure and analyse conditions leading to efficient electron heating and pre-acceleration. We confirm electron injection through shock-surfing acceleration in the foot of high Mach-number shocks and analyse additional electron energization processes due to spontaneous magnetic reconnection in the filamentary region of the turbulent shock ramp. We demonstrate a non-stationarity of the injection processes and their dependence on plasma temperature upstream of the shock and also on numerical parameters assumed in computer simulations. The relevance of our results to the physics of fully three-dimensional systems will also be discussed.

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