7 - 22 The Molecular-dynamics Simulation of the Electron Beam Relaxation and Adiabatic Acceleration*

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An 80 keV electron target with a lower electron temperature ($T_\perp < 5$ meV, $T_\parallel < 0.1$ meV) is proposed for the Spectrometer Ring(SRing) of High Intensity Heavy-ion Accelerator Facility (HIAF)[1–3]. To evaluate the designation of the acceleration process a numerical code based on the molecular dynamics method is developed to simulate the adiabatic acceleration process[4, 5]. In the code, many electrons are generated in a small box so that electron density can reach about 5.5×10^{12} m^{-3} to 1.5×10^{13} m^{-3}. The box has periodic boundary conditions longitudinally and open boundary conditions in radius direction in simulation[4, 5]. The box length and the radius are changed during the acceleration and the adiabatic expansion process to guarantee the current is constant at the different longitudinal positions.

The typical simulation results for electron target of HIAF are shown in Fig. 1. Figure 1(a) shows the evolutions of longitudinal temperature with time for the different longitudinal magnetic fields. Figure 1(b) shows the transverse-longitudinal relaxation rates depend on the longitudinal magnetic field obtained by simulations and empirical expression[4], it can be found that there is a resonable agreement between simulation results and the theoretical computation results. Figure 1(c) shows the dependence of the longitudinal temperature of the electron beam on the length of the accelerating tube obtained by simulations. It can be found that when the length of the accelerating tube increases the electron beam temperature decreases, and when the length of the accelerating tube larger than 1 000 mm the electron temperature nearly be a constant. From the results of the simulations one conclusion can be drawn is that for the electron target of HIAF the longitudinal temperature can be controlled to below 20 μeV by choosing the accelerating tube length larger than 50 cm($\overline{\lambda}_{\rm acc} < 0.6$).

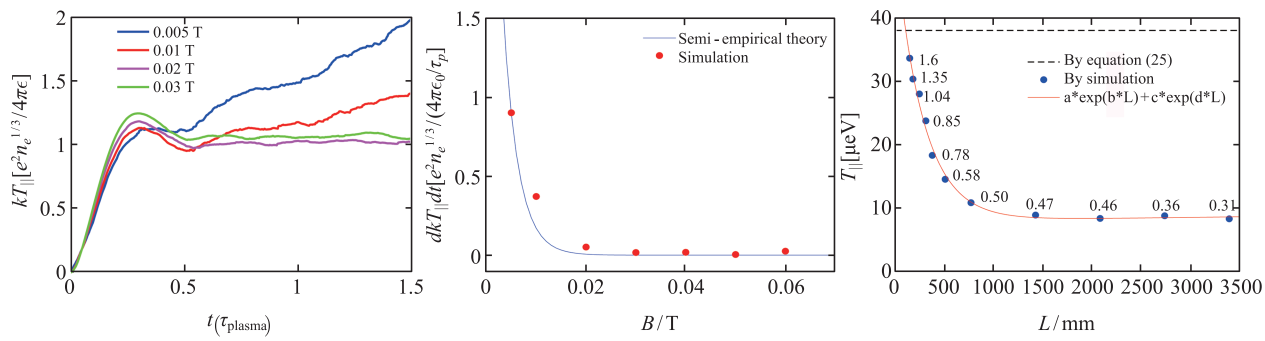

Fig. 1 (color online) The left panel is the evolution of longitudinal electron temperature with time for different magnetic fields obtained by the numerical simulation. The mid panel is the transverse-longitudinal relaxation rates depend on the longitudinal magnetic field. The simulated relaxation rates (red dot) are compared with the calculated data by the semi-empirical formula (blue solid lines). The right panel is the longitudinal temperature depends on the length of accelerating tube. The numbers beside the dots are corresponding average adiabatically parameters $\overline{\lambda}_{\rm acc}$.

References

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