§26. Coalescence of Two Current Loops in an Electron-Positron Plasma

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Electron-positron plasma are known to be sources of intense electromagnetic radiation from many objects in space, like the pulsar magnetospheres, the active galactic nuclear, and the early universe. Recent work has revealed that several sources are available to accelerate non thermal electrons and positrons. Seemingly study of a coalescence process in a pair plasma may disclose particle acceleration mechanisms. Our goal is to pursue this aim by performing numerical simulations with a 3-D particle code [1].

Figure 1 shows time history of the current-carrying electrons in a 3-D space. The current-carrying positrons behave in a similar way, and they are not plotted there. The same directional loops approach each other driven by the magnetic force, collide and coalesce. Prior to the coalescence, Buneman instability arises in each loop, resulting in bunching of the particles along the z-direction. The coalescence takes place at $w_{e}t=25$ associated with a drop of the magnetic field energy in the x-, z-directions accompanied by a gain in the y-direction. The induced electric field by the reconnection is remarkably exhibited. E_Z reaches a peak earlier than E_X, E_y due to the Buneman instability and saturates in the coalescence process. The transverse electric field is purely electromagnetic through the Faraday's law, since no charge separation in the perpendicular direction. The induced electric field is essential to particle acceleration in the reconnection region. The perpendicular kinetic energy grows and reaches a peak at the onset of the coalescence, and saturates. This variation is of the same way as the transverse electric field. On the other hand, the parallel kinetic energy increases due to the excitation of the Buneman instability before the coalescence. As the coalescence is going on, the particles are continuously accelerated by the saturated E_Z, and finally reach a constant level. In the steady coalescence phase, the loops split noticeably as that the electrons in the left loop rotate clock-wisely and the positrons unclockwisely. However, the species in the right loop do conversely. The break of the loops in accounted for by the B_Z drift. As foregoing mention, the ambient magnetic field B_Z is affected to change in the coalescence process. The signs of B_Z in the sides of the left and right loops are opposite, thereby the same species in the two loops are forced to be driven toward the reverse direction.

References

1) O. Buneman, *Computer Space Plasma Physics, Simulation Techniques and Softwares*, pp. 67 (Terra Scientific, Tokyo 1993)

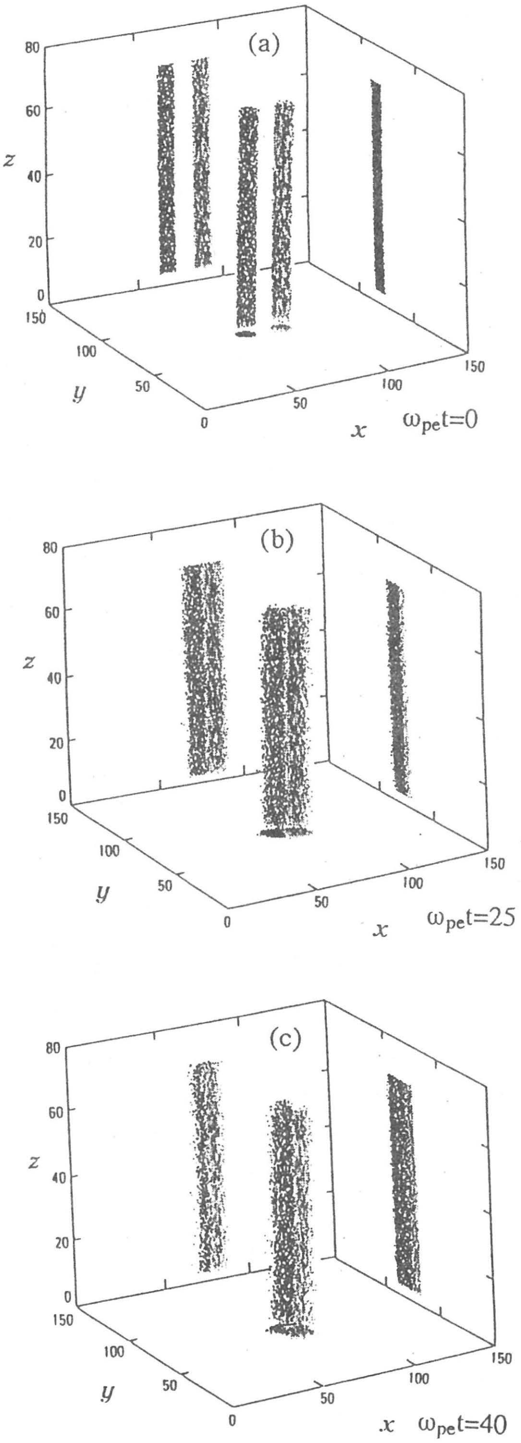

Fig. 1 Particles plot in the calculation box.