Formulation of the Self-Force on a Sheet Charge and Verification by Particle-in-Cell Simulations Using Ultra-Intense Lasers

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The purpose of this study is to derive formula of self-force acting on an infinite uniform sheet charge in 1D electrodynamics and verify it through 1D particle-in-cell (PIC) simulations. If the charged particle interacts with electromagnetic wave and accelerates, it emits radiation known as radiation reaction or self-force. In the case of point charge, self-force formula is established as Lorentz-Abraham-Dirac (LAD) force. In this paper, we derived the electromagnetic field produced by a sheet charge in motion. Then, we derived the self-force formula of a sheet charge by discretizing it into sub-sheets and calculating the force between each layer. To verify the formula, we compared it to 1D PIC simulations. The difference of velocity profiles between theoretical solutions and results of simulations was less than 0.5%. Moreover, we confirmed energy conservation using Poynting's theorem. By using our formula, we can get exact equation of motion of sheet charge. We believe this study can be utilized to analyze the motion of particle in ultra-intense energy situation.

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