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Issues in kinetic modeling of relativistic magnetic reconnection

Seiji Zenitani[1]

[1] Kobe University

e-mail: zenitani@port.kobe-u.ac.jp

Owing to its fundamental importance in high-energy astrophysics, kinetic modeling of magnetic reconnection in a relativistic plasma, has drawn huge attention in the past decades. In this contribution, we review two fundamental issues in particle-in-cell (PIC) modeling of relativistic magnetic reconnection.

First, we describe numerical algorithms to load relativistic velocity distribution functions (VDFs). In PIC simulations, researchers have to carefully initialize VDFs, but the numerical algorithms for relativistic VDFs are not widely known. To this end, we overview the Sobol method [1] to load a relativistic Maxwell VDF and then we propose volume-transform algorithms [2] to take care of the spatial part of the Lorentz transformation. We show that the volume transform method is crucial for relativistically hot VDFs. Without this, the VDFs are incorrectly modulated (Figure 1), and then the total energy flow is underestimated by 33%.

Second, we discuss fluid properties in relativistic particle populations. In the relativistic kinetic regime, fluid properties may not be straightforwardly obtained, because we can define the frame velocity in several different ways. After describing this problem, we apply an Eckart decomposition method [3] to an Ohm's law problem near the reconnection site, which was earlier investigated by Hesse and Zenitani [4]. We evaluate the stress-energy tensor from our PIC simulation results of relativistic magnetic reconnection in an electron-positron pair plasma (Figure 2). We have found that a new relativistic term in the Ohm's law partially sustains magnetic reconnection. From the particle viewpoint, the new term stems from high-energy particles that transport the out-of-plane momentum away from the midplane. This is consistent with conventional picture in the nonrelativistic regime. We further evaluate the energy balance around the reconnection site, based on our diagnosis.

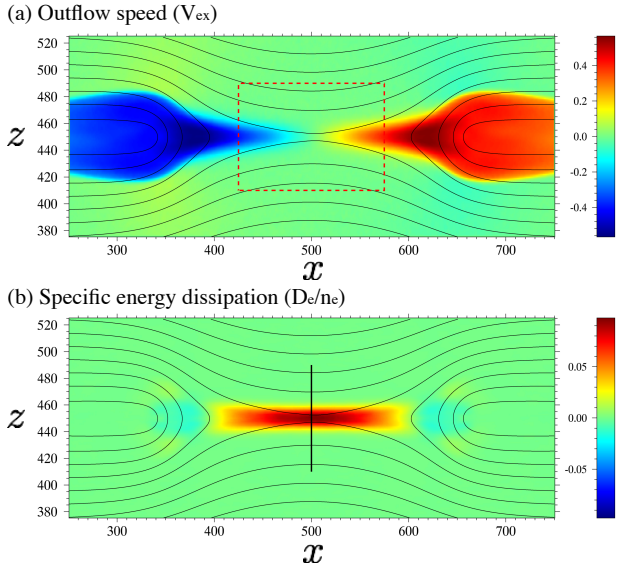

Figure 2: PIC simulation results of relativistic magnetic reconnection in an electron-positron pair plasma [3]

References

[1] I. M. Sobol, *On modeling certain distributions similar to gamma distribution*, in Monte Carlo Methods in Computational Mathematics and Mathematical Physics (Novosibirsk), pp. 24–29 (in Russian) (1976).

[2] S. Zenitani, *Loading relativistic Maxwell distributions in particle simulations*, Phys. Plasmas **22**, 042116 (2015)

[3] S. Zenitani, *Dissipation in relativistic pair-plasma reconnection: revisited*, Plasma Phys. Control. Fusion **60**, 014028 (2018)

[4] M. Hesse, S. Zenitani, *Dissipation in relativistic pair-plasma reconnection*, Phys. Plasmas **14**, 112102 (2007)

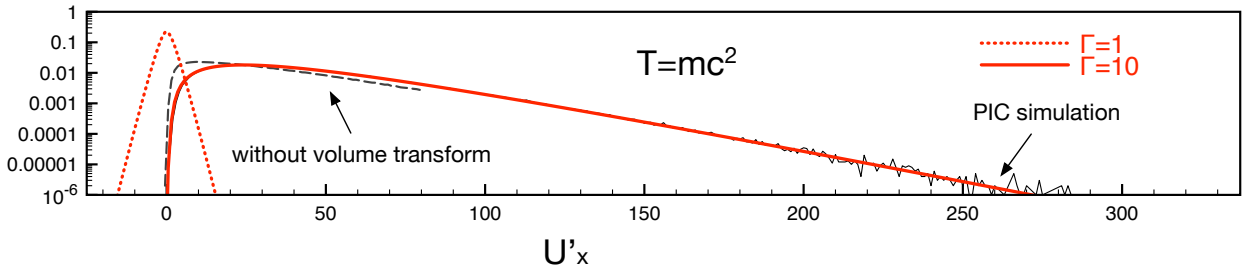

Figure 1: Distribution functions of Lorentz-boosted Maxwellians [2]. Numerical results (in black), analytic curves (in red), and an erroneous curve without volume transform (dashed black line) are presented.