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Electron Acceleration by Moderate-Mach-number Low-β Shocks

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Particle acceleration is ubiquitous at shock waves, occurring on scales ranging from supernova remnants in the universe to coronal-mass-ejection-driven shocks and planetary bow shocks in the heliosphere. The most promising mechanism responsible for the almost universally observed power-law spectra is diffusive shock acceleration (DSA). However, how electrons are pre-accelerated by different shocks to the energy required by the DSA theory is still unclear.

In our work, we perform two-dimensional particle-in-cell plasma simulations to investigate how the magnetic field orientations, with respect to simulation planes, affect electron pre-acceleration in moderate-Mach number low-β shocks. Simulation results show that instabilities can be different as the simulation planes capture different trajectories of particles. For magnetic fields perpendicular to the simulation plane, electron cyclotron drift instability [1] dominates in the foot. Electrons can be trapped by the electrostatic wave and undergo shock-surfing acceleration (Figure 1).

For magnetic fields lying in the simulation plane, whistler waves produced by modified two-stream instability [2, 3] dominate in the foot and scatter the electrons. In both cases, electrons undergo multistage acceleration in the foot, shock surface, and immediate downstream, during which process shock-surfing acceleration takes place as part of the pre-acceleration mechanism in moderate-Mach-number quasi-perpendicular shocks (Figure 2).

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References

[1] Yang, Z., et al., ApJL, 900, L24(2020b)
[2]Matsukiyo, S., Scholer, M. JGRA, 108, 1459(2003)
[3]Scholer, M., Burgess, D., PhPl, 14, 072103(2007)

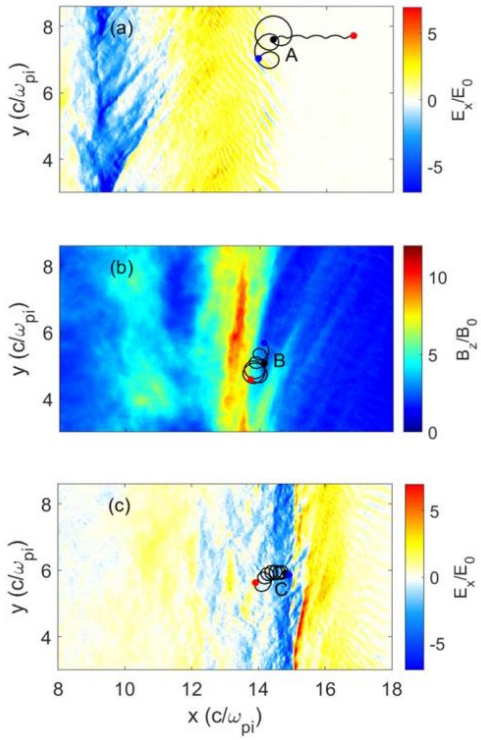

Figure 1: The electron's trajectory and its position with respect to the shock (out of plane)(a)–(c): Ex(t = 3.6), Bz(t = 4.6), and Ex(t = 5.0). The start time is indicated by the red dot, whereas the blue dot denotes the end time. The start and end times of each subplot: (a) t = 3.3–3.9, (b)t = 4.4–4.73, and (c) t = 4.74–5.1.

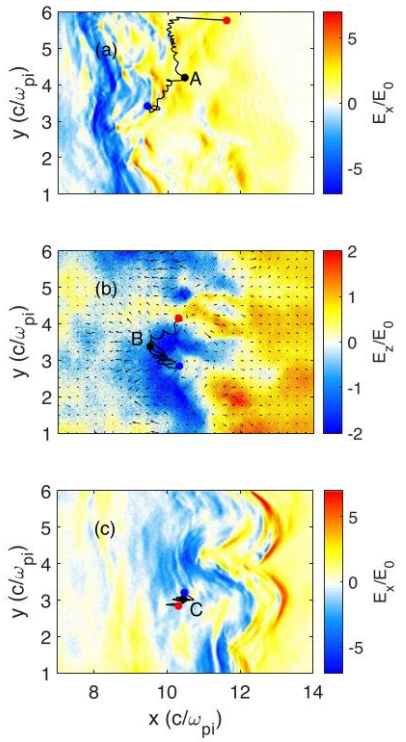

Figure 2: The electron's trajectory and its position with respect to the shock (in plane): electric field Ex (t = 3.6), electric field Ez (t = 4.2), and electric field Ex (t = 4.5). The start and end times of each subplot: (a) t = 3.1–3.8, (b)t = 4–4.4, and (c) t = 4.4–4.6. The arrows in (b)indicate vector (Ex, Ey).