

Abstract Submitted
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Nonthermal Acceleration in Relativistic Collisionless Shocks

ANATOLY SPITKOVSKY, Princeton University — Modeling of nonthermal emission from relativistic outflows in astrophysics commonly leads to the conclusion that relativistic collisionless shocks accelerate nonthermal particles. Yet, such acceleration has not been detected so far in self-consistent particle-in-cell simulations of collisionless shocks, raising questions about both the underlying mechanism and the applicability of such simulations. We present here the first evidence of nonthermal acceleration in unmagnetized relativistic shocks in pair plasma found in a long-term large-scale particle-in-cell simulation. Accelerated particles appear as a distinct power-law tail on top of the thermal downstream distribution. The particles are accelerated in the self-generated magnetic turbulence of the Weibel instability that mediates unmagnetized shocks. By tracing particle orbits we find that particles gain most energy when they bounce between the upstream and downstream regions surrounding the shock transition, implying Fermi-I type of acceleration. By contrast, magnetized pair shocks (mediated by coherent magnetic reflections of particles rather than Weibel instability) do not show nonthermal acceleration in the relativistic limit due to insufficient downstream turbulence. These simulations place constraints on the magnetization of astrophysical pair plasmas that can produce nonthermal radiation. Extensions to electron-ion plasmas will also be discussed.

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