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Nonlinear Diffusive Shock Acceleration in GRB Afterglows

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The standard synchrotron afterglow model has been applied to enormous success since its original formulation. In spite of the variety of extensions and refinements made to the basic model, virtually all work on GRB afterglows has ignored two critical aspects of shock acceleration. First, it ignores the significant population of thermal particles that must be present downstream but are not part of a power law distribution. Second, particle-in-cell simulations show that relativistic shocks are efficient enough accelerators that the accelerated cosmic rays modify the shock structure away from the test-particle limit.

We will discuss a new model for GRB afterglows using Monte Carlo simulations. Our model takes into account the highly nonlinear interaction between efficient shocks and the cosmic rays they accelerate. It additionally includes all particles, and not just cosmic rays, in the calculations of photon production. Each of these enhancements makes an observable difference to the spectra and light curves expected.

We will also discuss how a more realistic magnetic field structure, which reaches near-equipartition levels near the shock itself, affects the ability of GRB forward shocks to accelerate protons up to – or even beyond – the ankle of the cosmic ray spectrum observed at Earth.

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