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Physics of GRB afterglows: general principles and application to notable GRBs

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GRB afterglows are powered by emission from relativistic collisionless shocks. The converter acceleration mechanism, which is specific just for relativistic shocks, makes them efficient emitters and at the same time modifies the shock structure. As a result, the shock balances itself within a region in the parameter space that can be estimated analytically or evaluated numerically with a good precision. This constitutes the pair balance model for relativistic shocks, which allows one to predict afterglow spectra from the first principles.

To test the pair balance model one needs an afterglow where both the synchrotron and inverse Compton (TeV) components are observed simultaneously. Then one can resolve degeneracy inherent to the general synchrotron-self-Compton framework and determine the parameters of the emitting region.

Two notable examples of simulataneous X-ray and TeV observations are GRB 190114C (early afterglow, few minutes since the trigger) and GRB 190829A (late afterglow, beginning from 10 hours after the trigger). Although two GRBs belong to fairly distant evolutionary stages, their parameters (determined from broad-band spectra) fit nicely into predictions of pair-balance model of relativistic shocks.

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