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The influence of pair production upstream of relativistic collisionless shocks

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Among other powerful relativistic astrophysical objects, gamma-ray bursts, blazars and pulsar winds provide an ideal environment to understand the acceleration mechanisms of high-energy charged particles. The radiative spectra observed in such objects are generally attributed to particles energized in relativistic collisionless shock waves. In this presentation, we investigate the backreaction on the shock dynamics of pair production due to photon-photon collisions in the upstream region. Initially, the shock generates a distribution of Fermi-accelerated suprathermal particles, which progressively cool down through synchrotron emission in the downstream electromagnetic turbulence. The resulting high-energy photons propagate upstream of the shock at the speed of light, where they decay into electron-positron pairs via the Breit-Wheeler process. Through plasma micro-instabilities, those pairs cause the plasma to heat up and slow down. This modifies the shock jump conditions, up to a critical pair injection level where the shock eventually disappears. When this happens, the Fermi acceleration stops, and only a weakening radiation background fed by the leftover suprathermal particles remains in the upstream plasma. The pair injection rate then drops, thus allowing the shock to reform. The problem is investigated by use of analytical models describing the respective phases and by comparison with ab initio, large-cale kinetic simulations.

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