Particle Acceleration through Multiple Conversions from Charged into Neutral State and Back
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abstract

We propose a new way of quick and very efficient acceleration of protons and/or electrons in relativistic bulk flows. The maximum achievable particle energies are limited either by radiative losses or by the condition of confinement in the magnetic field. The new mechanism takes advantage of conversion of particles from the charged state (protons or electrons/positrons) into neutral state (neutrons or photons) and back. In most cases, the conversion is photon-induced and requires presence of intense radiation fields, but under special circumstances the converter acceleration mechanism may operate via other charge-changing reactions, for example, inelastic nucleon-nucleon collisions.

Like in the traditional model – “stochastic” (or diffusive) acceleration, – the acceleration cycle in our scenario consists of escape of particles from the relativistic flow followed by their return back after deflection from the ambient magnetic field. The difference is that the charge-changing reactions, which occur during the cycle, allow accelerated particles to increase their energies in each cycle by a factor roughly equal to the bulk Lorentz factor squared.

The emerging spectra of accelerated particles can be very hard and their cut-off energy in some cases is larger than in the standard mechanism. This drastically reduces the required energy budget of the sources of the highest-energy particles observed in cosmic rays. Also, the proposed acceleration mechanism may serve as an efficient means of transferring the energy of bulk motion to gamma-radiation and, if the accelerated particles are nucleons, routinely produces high-energy neutrinos at $\sim 50\%$ relative efficiency.