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Rapid particle acceleration at perpendicular shocks

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Perpendicular shocks are shown to be rapid astrophysical particle accelerators. They perform optimally when the ratio of the shock speed to the particle speed roughly equals the ratio of the scattering rate to the gyro frequency. Analytical methods and Monte-Carlo simulations are used to solve the kinetic equation that govern the anisotropy generated at these shocks, finding a softer spectral index than the standard result of diffusive shock acceleration, and an acceleration time significantly shorter than the frequently quoted “Bohm limit”. Amongst other implications, these results provide a theoretical basis for the thirty-year-old conjecture that a supernova exploding into the wind of a Wolf-Rayet star may accelerate protons to an energy exceeding 10^{15} eV.

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