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The First and Second-Order Fermi Acceleration Processes in BL Lacertae Objects

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BL Lacertae objects (BL Lacs) constitute a rare class of active galactic nuclei (AGNs) with the extreme observational features attributed to the Doppler-boosted emission from a relativistic jet, closely aligned to our line-of-sight. The spectral energy distribution (SED) of these sources, extending over 17-19 orders of the frequency from radio to the TeV energy range, is of non-thermal origin and shows a typical two-component structure. The lower-energy component, ranging from the radio-band to X-rays, is widely accepted to be a synchrotron radiation emitted by ultra-relativistic electrons/positrons/protons, to be initially accelerated via the Blandford-Znajek mechanism or magneto-hydrodynamic processes in the vicinity of the central supermassive black hole. However, the accelerated particles should loose the energy, sufficient for the emission of the KeV-GeV photons, very quickly and the source can maintain its flaring state on the daily-weekly timescales only if some additional acceleration mechanisms are continuously at work. According to the different studies and simulations, the particles can gain a tremendous energy due to the propagation of relativistic shocks through the jet: by means of first-order Fermi mechanism at the shock front, or they undergo an efficient stochastic (second-order Fermi) acceleration close to the shock front, in the turbulent jet medium. Our intensive X-ray spectral study of the TeV-detected, bright BL Lacs (Mrk 421, 1ES 1959+650, Mrk 501) often shows the signatures of the stochastic acceleration , while those related to the first-order Fermi process are found relatively rarely. The TeV-undetected HBLs mostly do not show the signatures of effective stochastic acceleration in their jets.

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