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Background field method and nonrelativistic QED matching

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We discuss the resolution of inconsistencies between the background field method in lattice QCD and the effective field theory matching conditions. Lack of on-shell conditions in lattice QCD with time-dependent background fields requires that operators related by equations of motion in the effective field theory should be retained in the action to describe the Green's function correctly. As a concrete example, we perform a robust non-relativistic expansion of the relativistic QED action for scalar and spin-half hadrons under uniform electromagnetic fields, and obtain the nonrelativistic QED matching conditions including the equation-of-motion operators. For a scalar hadron, this result is also supported by the matching at the level of the Green's function. The method is extended to treat the proton in uniform electric and magnetic fields, where Landau levels are addressed in the latter case to allow determination of the magnetic polarizability.

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