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Quasiclassical approach and high energy QED processes in the field of a heavy atom

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QED processes at high energies in the field of a heavy nucleus or an atom are classical examples of processes in strong fields. They are exhibited in numerous experimental setups, including those designed for completely different purposes, being quite unrelated to an observation of these processes. Their investigation, therefore, has an obvious practical value. From a theoretical point of view, these processes are interesting, since they provide an important insight into the structure of higher-order effects in perturbation theory.

A general approach to strong-field calculations is the use of the Furry picture. In this approach the wave functions and propagators of a particle are replaced by exact solutions and Green functions of wave equations in external fields. The general feature of an exact Green function of a relativistic equation is the existence of a sum of angular momentum which cannot be expressed in a closed form. At high energies of initial particles, the final particle momenta usually have small angles with respect to the incident direction. In this case the typical angular momenta that provide the main contribution to the cross section are large, $l \sim \varepsilon/\Delta \gg 1$, where ε is energy and Δ is momentum transfer. The sum of angular momentum converges slowly. Due to such complications, computations based on this expression become rapidly intractable with the growth of particle energy. Fortunately, this is the reason for the quasiclassical approximation based on large angular momenta contributions to come into play. In this approximation, the wave functions and Green functions of the Dirac equation in external fields acquire a very simple form, which simplifies the calculations drastically. The quasiclassical Green functions have been derived for a localized field which generally exhibits no spherical symmetry. One of the main features of the quasiclassical approach is a possibility to calculate not only the leading order term but also the next-to-leading order quasiclassical correction. This approach provides a possibility to investigate numerous QED processes in the field of a heavy atom.

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