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Twisted electron in a strong laser wave

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It has recently been discovered theoretically [1] and proved experimentally [2] that free electrons can carry orbital angular momentum being as large as $m \sim 100\hbar$ [3]. These \textit{twisted electrons} can be considered as massive analogs of the well-known \textit{twisted photons} whose Pointing vector rotates about the direction of their propagation. We consider such an electron with orbital angular momentum and spin (and, consequently, spin-orbital connection) moving in external field of a plane electromagnetic wave. It is studied how the orbital angular momentum modifies motion of the electron and the simplest radiation processes like Compton effect. In particular, motion of a twisted electron in the circularly polarized wave reveals twofold quiver character: the wave-packet center moves along the classical helical trajectory accompanied with the pure quantum vibrations around it due to the orbital angular momentum. We present the exact solution of the Dirac equation, which describes a "non-Volkov" state with orbital angular momentum and, consequently, generalize the free-electron Bessel state. Using these twisted states, we calculate the total angular momentum of the electron in the laser wave and predict its shift in a classically strong-field regime ($-e^2\bar{A}^2/m^2$ $gtrsim1$) that is analogous to the well-known shift of the electron's momentum and mass (and to a less known shift of its spin) in the strong laser fields. Since the effective total angular momentum of the electron is preserved in the azimythally symmetric fields, we discuss some possibilities for accelerating the non-relativistic twisted electrons.

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