The QED Hamiltonian in the Clothed-Particle Representation (CPR)

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Relying upon an experience [1] in constructing relativistic interactions for the meson-two-nucleon system we will show one more application of the method of unitary clothing transformations (UCTs) [2,3], now, in QED (cf. [4]). Our departure point is to express the total Hamiltonian H_{qed} of interacting photons, electrons and positrons with the primary Yukawa-type coupling through new operators for the creation and destruction of the "clothed" particles with physical properties (in our case photons, electrons and positrons) and their relativistic interactions. In such a form H_{qed} becomes dependent upon the renormalized particle masses instead of the "bare" ones, so particles in the CPR may be regarded as quasiparticles in the quantum field theory to identify them with the observed particles. The corresponding Hermitian and energy-independent four-operator interactions for the $2 \leftrightarrow 2$ processes (such as $e^{\pm} + e^{\pm} \to e^{\pm} + e^{\pm}$ and $e^{-} + e^{+} \leftrightarrow \gamma + \gamma$) and five-operator interactions for the $2 \leftrightarrow 3$ ones (such as $e^{\pm} + e^{\pm} \leftrightarrow \gamma + e^{\pm} + e^{\pm}$) are derived along the chain: bare particles with bare masses $\to$ bare particles with physical masses $\to$ physical (observable) particles. These types of interaction have a distinctive off-energy-shell structure which is naturally generated by the unitary transformation that removes from the Hamiltonian the (three-leg) γee vertex coupling. We emphasize that only the on-energy-shell matrix elements of the interaction operators coincide with those given by the Feynman rules. A set of the coupled eigenvalue equations for electron-positron states is automatically derived to be used in the positronium theory. Our consideration is compatible with the relativistic invariance requirements being fulfilled in the framework of an original procedure [5,6] proposed to meet the Poincaré-Lie algebra.

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