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Quantum fermionic charged particle self-interaction problem within the Fock multi-time and Feynman proper time paradigms Analysis of polarization coding for subcarrier multiplexing quantum key distribution

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The elementary point charged particle (e.g. electron), mass problem inspired physicists [Jamm</cite> from the past such as J. J. Thompson, G.G. Stokes, H.A. Lorentz, E. Mach, M. Abraham, P.A. M. Dirac, G.A. Schott, J. Schwinger] and many others. Nonetheless, their studies have not given rise to a clear explanation of this phenomenon, which stimulated new researchers to tackle it from different approaches based on new ideas stemming both from the classical Maxwell-Lorentz electromagnetic theory, as in [Bril,GiZa-1,GiZa-2,Pryk-Ampe,Feyn-1,Feyn-2,Hamm-1,Hamm-2,Rohr,Schw], and modern quantum field theories of Yang-Mills and Higgs type, as in [Anni,Higg,Hoof,Wilc-2] and others, whose recent and extensive review appears in [Wilc-1]. In the present work we mostly concentrate on detailed quantum and classical analysis of the self-interacting shell model charged particle within the Fock multi-time approach [DiFoPo,FoPo] and the Feynman proper time paradigm [Feyn-1,Feyn-2,Dyso-1,Dyso-2] subject to deriving the electromagnetic Maxwell equations and the related Lorentz like force expression within the vacuum field theory approach devised in works [BlBoPr,BoPr-foun,BoPr-Feyn,BoPr-Lore,BoPr-math,BoPrBl,GiZa-1,GiZa-2,GiZaLi]. Furthermore, we explain and apply the obtained results to treating the classical H. Lorentz and M. Abraham [Abra,Lore-1,Lore-2,Lore-3,Kosy-1,Kosy-2,MaPi,Medi,Moro,Page,Papp,Pegg,Puth,Rohr-1,Simu,Teit,WhFe,YaTr] electromagnetic mass origin problem. For the first time the proper time approach to classical electrodynamics and quantum mechanics was apparently suggested in 1937 by V. Fock [Fock], in which, in particular, there was constructed an alternative proper time based Lagrangian description of a point charged particle in an external electromagnetic field. A more detailed motivation for using the proper time approach was later presented by R. Feynman in his Lectures [Feyn-1] Concerning the alternative and much later investigations of the a priori given quantum electromagnetic Maxwell equations in the Fock space one can mention the Gupta-Bleiler [Gupt,Bleu,BoSh] and [Ferm,Schw,BjDr] approaches. As is well known [BjDr,BoSh], the first approach contradicts one of the most important field theoretical principles - the positive definiteness of the quantum event probability and is strongly based on making nonphysical use of an indefinite metric on quantum states. The second one is completely non-relativistic and based on the canonical quantization scheme [BjDr,Schw-1] in the case of the Coulomb gauge condition. Inspired by these and related classical results, we have shown that the self-interacting quantum mechanism of the charged particle with its self-generated electromagnetic field consists of two physically different phenomena, whose influence on the structure of the resulting Hamilton interaction operator appeared to be crucial and gave rise in [PrBo-mass] to a modified analysis of the related classical shell model charged particle within the Lagrangian formalism. As a result of our scrutiny of studying the classical electromagnetic mass problem there was demonstrated that it can be satisfactory solved within the classical H. Lorentz and M. Abraham arguments augmented with the additional electron stability condition, which was not taken before into account yet appeared to be very important for balancing the related electromagnetic field and mechanical electron momenta. Their importance, following the recent works [Puth,Moro,Rohr-1] devoted to analyzing the electron charged shell model, was realized within there suggested pressure-energy compensation principle, suitably applied to the ambient electromagnetic energy fluctuations and the self-generated electrostatic Coulomb electron energy. In the case of a point charged particle the alternative relativistic invariant approach to studying the radiation reaction force was suggested earlier by Teitelbom [Teit] This approach was based on a formal relativistic invariant splitting of the electromagnetic energy-momentum tensor and derivation of the related suitably renormalized charged particle equations of motion.

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