On the possible mass terms for Pseudo Quantum Electrodynamics

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For a single layer graphene in its usual conductive phase, the electromagnetic interactions among electrons is very well described by the Pseudo Quantum Electrodynamics (PQED), which can be understood as a (2+1)-dimensional description of a (3+1)-dimensional structure with currents constrained to a plane but the photons associated to the interaction among charges can roam in a third spatial dimension (perpendicular to the plane). An important physical realization of the PQED model is the electromagnetic field between two Dirac fermions constrained to move in a *xy* plane, while the photons exchanged by them can travel in the *z* direction, escaping and returning back to the plane. The PQED model provides a strictly planar description of this kind of (3+1)-dimensional system, in the sense that the PQED propagator has the same expression as usual (3+1)-dimensional Quantum Electrodynamics (QED_4) when the currents of the QED_4 are constrained to a plane. Although the PQED results in description of electromagnetic interaction among charges in planar systems are excellent, we note that PQED presents no mass term for the gauge field and that in superconductor systems, the Anderson-Higgs mechanism implies in a mass term for the force transmitting gauge field. In other words, we can say that photons behave like massive particles in superconductors. Hence, if we intend to describe electromagnetic interactions among charges in planar superconductors through a reduced model, we might need to investigate how to endow the gauge field with mass and, in this work, we analyze some possible forms to add a mass term in the PQED Lagrangian, studying the mathematical structure and the physical behavior (in terms of the asymptotic freedom) of the gauge field propagators.