ON-SHELL CALCULATION OF FIELD STRENGTH AND CHARGE COUNTERTERMS IN ARBITRARY COVARIANT GAUGE IN SCALAR QED

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Quantum Field Theory is an extremely successful framework in particle physics. For example, the Standard Model is also a QFT with specific particle content that describes our world with astonishing precision. However, in order to actually compare the theory with experiment, QFT has quite a few obstacles that have to be overcome. These obstacles manifest even in simple theories such as scalar Quantum Electrodynamics (sQED)[1]. Generally, for perturbative regimes, one draws Feynman diagrams, performs appropriate calculations and all is good at tree level. Unfortunately, already at one-loop level some calculations give infinite contributions while what we observe is manifestly finite, hence, it is needed to find a way to get rid of the infinities in a physical, technical and consistent way - it is needed to *renormalize* the theory. However, there are quite a few choices when renormalizing a theory - gauge, regulator, and subtraction scheme may all be nearly freely chosen. Some specific gauges allow to neglect entire Feynman diagrams, regulators consistently separate the infinities, and subtraction schemes define the finite parts of counterterms. In addition, there may be non-trivial relations between counterterms and even an additional type of divergences can appear, which renormalization cannot remove.

In this work, to better understand the technicalities in renormalization, we chose to compute two non-trivially related counterterms for the field strength and charge in sQED. The computation is done in arbitrary ξ gauge and in the On-Shell subtraction scheme [1] with dimensional regularization [2] in $d = 4$ dimensions.

[1] Matthew D. Schwartz, *Quantum Field Theory and the Standard Model*, Cambridge University Press, 2014, ISBN: 1107034736, 9781107034730

[2] C. G. Bollini and J. J. Giambiagi, *Dimensional renormalization: The number of dimensions as a regularizing parameter*, Il Nuovo Cimento B (1971-1996), 12.1 (1972), pp. 20-26, ISSN: 1826-9877