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Conformal Gauges and Renormalized Equations of Motion in Massless Quantum Electrodynamics

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To the memory of Kurt Symanzik

Abstract. A formulation of massless QED is studied with a non-singular Lagrangian and conformal invariant equations of motion. It makes use of non-decomposable representations of the conformal group G and involves two dimensionless scalar fields (in addition to the conventional charged field and electromagnetic potential) but gauge invariant Green functions are shown to coincide with those of standard (massless) QED. Assuming that the (non-elementary) representation of G for the 5-potential which leaves the equations of motion invariant and leads to the free photon propagator of Johnson-Baker-Adler (JBA) conformal QED remains unaltered by renormalization, we prove that consistency requirements for conformal invariant 2-, 3-, and 4-point Green functions satisfying (renormalized) equations of motion and standard Ward identities lead to either a trivial solution (with $e\psi=0$) or to a subcanonical dimension $d=\frac{1}{2}$ for the charged field.

1. Introduction

The search for a conformal invariant quantum field theory (QFT) is one way to look for a (critical) renormalization group fixed point (see, e.g., [S2] where the essential equivalence between the two problems has been spelled out). It is, therefore, intimately related to the existence problem for a local relativistic QFT (see [A3, F5, M5]).

The study of conformal quantum electrodynamics (QED) [J1, A1, 2, E1, M4, F6, B1] (see also Chap. VII to [T1]) differs in at least two points from a parallel investigation of a nongauge, Yukawa-type QFT (see [M2, 3, D3, 4, F4, T1] and references therein). First, current conservation and the Maxwell equations imply that the dimension of one of the basic fields, the 4-potential $A_\mu(x)$, is canonical (while the dimension of the charged field $\Psi(x)$ is gauge dependent). Secondly, although conformal invariance of the classical (vacuum) Maxwell equations has been known since the time when application of group theory to physics was a novelty (see [C1, B2]), the problem of finding a conformal invariant gauge fixing