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Pure Massless Electrodynamics in Veltman's Gauge

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Abstract. To show how the method developed by C. Becchi, R. Stora and the present author to prove Slavnov's identities in gauge theories works in Abelian cases including a nonlinear gauge without any discrete symmetry, a specific example is worked out, exhibiting the details of the technical procedure.

I. Introduction

Recently Becchi, Stora and the present author have developed a method for proving Slavnov identities in gauge theories [1] which relies on very general theorems of renormalization, more precisely a quantum version of the Schwinger action principle; the proof consists in an extensive use of consistency conditions. However, the proof given was restricted to massive semi-simple cases with linear gauge; a specific Abelian case was also studied [2], but we used a discrete symmetry to simplify the problem. Generalizations of this method to the massless case were studied by Lowenstein [3] and Becchi [4] (pure Yang-Mills theory) and Clark and the present author [5] (Georgi-Glashow model).

The generalization to cases including Abelian subgroups with linear gauges was given by Becchi, Blasi and Collina [6]; there the couplings of the Faddeev-Popov ghost related to the Abelian subgroup are assumed to be superrenormalizable. Here we give an example of what has to be done in a case including a nonlinear gauge, when no discrete symmetry simplifies the problem, and when the couplings of the Abelian Faddeev-Popov ghosts are not superrenormalizable. The example given is pure massless electrodynamics in a Veltman type gauge [7].

Section II is devoted to the definition of the model in the tree approximation; in Section III the quantum action principle is recalled; Section IV is devoted to the proof of the Slavnov identity at any order.

II. Definition of the Model in the Tree Approximation

Let us consider pure massless electrodynamics in the nonlinear gauge

$$\mathcal{G} = \partial_\mu a^\mu + \varrho a_\mu a^\mu ,$$

as proposed by Veltman [7]; c and $\bar{c}$ will denote the Faddeev-Popov ghosts.