



BRS “Symmetry”, the main role of Raymond Stora

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Abstract

We discuss how Raymond Stora’s absolute need of mathematical rigor has determined the discovery of BRS “Symmetry”. This need having been the essential reason for the construction of the identity which has been presented by Rouet and Stora in the lectures given at Lausanne-1973. Once written this identity the celebrated discovery has been a matter of reading. We also recall the less celebrated discovery of BRS cohomology and its impact on Physics.

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1. Discussion

In this volume dedicated to the memory of Raymond Stora I think that a short look at the history of the discovery of BRS “Symmetry” is certainly in order. In particular this historical analysis is crucial to single out Raymond’s role in the discovery.

As it often happens in Physics, the discovery has been the end of a long sequence of steps which begun with ’t Hooft’s 1971 paper [1]. After Faddeev–Popov’s [2] work a general agreement was reached about the form of the Lagrangian and hence of Feynman rules, the remaining items to be discussed being essentially renormalizability, gauge choice independence, locality and unitarity, together with possible generalizations to e.g. gravity.

With this purpose the first analyses were devoted to the extension to the Yang–Mills theory of the Ward Identity of QED which expresses at the level of Green functions the freedom of the scalar component $\partial_\mu A^\mu \equiv \partial A$ of the gauge field. This was done by ’t Hooft in the cited paper

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which however was limited to the amplitudes on the mass-shell (see 't Hooft's paper in this volume). The extension of 't Hooft's paper off mass-shell was done by Taylor [3] and Slavnov [4] studying the properties of the Green functions under non-local gauge transformations.

However it was known (by a limited number of physicists) that locality is not only one of the bases of axiomatic quantum field theory, but also a crucial ingredient of renormalization. This fact was perfectly understood by Raymond as it is proved by many contributions to the present volume (see e.g. Todorov's, Popineau–Stora's, ..., and, of course, 't Hooft's).

The “natural” improvement in this direction was the interpretation of Faddeev–Popov's ghosts as local fields which led, also thanks to Claude Itzikson, to the identity presented by Rouet and Stora (RS) in the lecture notes of the *Enseignement du troisième cycle de la Physique en Suisse Romande* in 1973 [5], which was and still is mistaken as an equivalent version of the Slavnov–Taylor identity. It took a while (nine months) before the real content of the RS identity appeared clearly leading to the BRS construction [6] of gauge theories.

The BRS invariance of the theory being an “obvious” consequence of Rouet and Stora's identity, a crucial and highly non-trivial step in the BRS construction was the discovery that (initially on the ghost mass-shell) the BRS transformations are nilpotent. This introduced the idea of **BRS cohomology** [7–11].

BRS cohomology, however less celebrated than the corresponding symmetry (may be due to the strangeness of the name), has a very important role in Physics because it defines the physical content of a generalized gauge theory (e.g. string theory) possibly beyond the perturbative level [12]. Indeed, while in the perturbative approach it is the instrument identifying potential anomalies, as a matter of fact this is the reason of its discovery, in general it identifies the physical content of a theory because physical observables must be BRS invariant, while, due to nilpotency, the BRS transformation of an operator is also invariant. It is however trivial for the same reason.

Therefore physical operators must belong to the space of the BRS invariant operators which are not the result of a BRS transformation. This is called (BRS) cohomology by mathematicians.

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