

Existence, Uniqueness and Cohomology of the Classical BRST Charge with Ghosts of Ghosts

Jean Fisch,^{1,*} Marc Henneaux,^{1,2,3,**} James Stasheff,^{4,5} and Claudio Teitelboim^{2,3}

¹ Faculté des Sciences, Campus Plaine C.P.231, Université Libre de Bruxelles, Bruxelles, Belgium

² Center for Relativity, University of Texas at Austin, Austin, Texas 78712, USA

³ Centro de Estudios Científicos de Santiago, Casilla 16443, Santiago 9, Chile

⁴ Mathematics Department, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina 27514, USA

⁵ School of Mathematics, Institute for Advanced Study, Princeton, New Jersey 08540, USA

Abstract. A complete canonical formulation of the BRST theory of systems with redundant gauge symmetries is presented. These systems include p -form gauge fields, the superparticle, and the superstring. We first define the Koszul–Tate differential and explicitly show how the introduction of the momenta conjugate to the ghosts of ghosts makes it acyclic. The global existence of the BRST generator is then demonstrated, and the BRST charge is proved to be unique up to canonical transformations in the extended phase space, which includes the ghosts. Finally, the BRST cohomology in classical mechanics is investigated and shown to be equal to the cohomology of the exterior derivative along the gauge orbits, as in the irreducible case. This is done by re-expressing the exterior algebra along the gauge orbits as a free differential algebra containing generators of higher degree, which are identified with the ghosts of ghosts. The quantum cohomology is not dealt with.

I. Introduction

The most transparent and useful formulation of a field theory appears to be one in which locality is manifest. This also makes relativistic invariance manifest, since locality ensures that signals do not propagate at infinite speed.

It appears in practice that, for systems of physical interest, manifest locality can be maintained only at the price of formulating the theory in terms of more variables than what would naively seem to be necessary. One then obtains what is called a gauge theory.

* Aspirant du Fonds National de la Recherche Scientifique (Belgium)

** Chercheur qualifié au Fonds National de la Recherche Scientifique (Belgium)