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Charged States in $\mathbb{Z}_2$ Gauge Theories

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Abstract. Charged translation covariant states with finite energy are constructed in the Higgs phase of the $\mathbb{Z}_2$ gauge theory coupled to a $\mathbb{Z}_2$ matter field.

1. Introduction

The spectrum of charges in gauge theories depends on subtle properties of the dynamics, and it is extremely difficult to get information on them within the known approximation schemes. An easier problem is the investigation of lattice gauge theories where the powerful methods of classical statistical mechanics can be applied, and one may hope that certain properties of the lattice theory will survive in the continuum limit. However, on the lattice the investigation of the charge structure is not easy either. The emphasis has rather been on confinement criteria, the most prominent one being the Wilson criterion [1]. This criterion checks whether the energy of a system with two external charges increases linearly with the distance between the charges. If this happens, it is interpreted as a sign that it is impossible to create single charges with finite energy. Unfortunately, the Wilson criterion cannot be used to test the existence of dynamical charges in gauge theories with matter fields [2]. This is however the more interesting question. Criteria which are applicable in this case have been proposed by Mack and Meyer [3] and Bricmont and Fröhlich [4]. However, the implications of their criteria for the confinement problem are not clear.

The aim of this work is to understand the nature of charges in a gauge theory with matter fields. Our analysis leads to confinement criteria which directly test the existence of charges [5] and some of their most relevant properties.

In gauge theories with a discrete gauge group there exists a weak coupling expansion. In the pure gauge theory the Wilson loop obeys a perimeter law [6–8, 2]. One may ask whether charged states with finite energy will exist if the gauge field is coupled to a matter field. This has been conjectured by several

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