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

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Abstract. In the free charge phase of the $\mathbb{Z}_2$ gauge-Higgs model on a lattice charged particles are shown to exist.

1. Introduction

Charged particles in gauge theories cannot be created by applying local fields to the vacuum. In a massive theory, this fact leads to strong restrictions for charged particles to exist. In relativistic quantum field theory [1] as well as in a certain class of Hamiltonian lattice theories [2], it has been shown that in a particle state expectation values of local observables approach at spacelike infinity rapidly the vacuum expectation values. In a case where the total charge is the sum over the electric fluxes at spacelike infinity as in $U(1)$ gauge theories, it therefore must vanish (Swieca's theorem [1–4][1]). If however, the gauge symmetry is multiplicative like the triality in $SU(3)$ gauge theories, this conclusion is no longer valid, and charged particles may exist, provided the electric fluxes in different directions are strongly enough correlated. The absence of such correlations may be used as a criterium for confinement [5].

In [6] charged states of the $\mathbb{Z}_2$ gauge-Higgs model [7, 8] in the so-called free-charge phase (Fig. 1) have been constructed. This phase is massive, and the general discussion applies. It was left open in [6] whether there are particles in the charged sector. This gap will be closed by the present paper.

The starting point of our analysis is the euclidean Green's function in the charged sector:

$$G(x_0, \mathbf{x}) = (\Phi, U(\mathbf{x}) T^{|x_0|} \Phi) \ , \tag{1.1}$$

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[1] Note that the arguments in [2] and [1] do not use Lorentz covariance, in constrast to the original argument of Swieca [3] and the treatment in [4]