Commun. Math. Phys. 108, 423–436 (1987)

Communications in Mathematical Physics

Global Symmetry Restoration in High Temperature Higgs Theories

Chris King* and Laurence G. Yaffe**, ***

Joseph Henry Laboratories, Department of Physics, Princeton University, Princeton, NJ 08544, USA

Abstract. A simple high temperature expansion is developed for lattice gauge theories with scalar matter fields. The expansion is used to prove the absence of global symmetry breaking for sufficiently high temperature.

I. Introduction

In both statistical mechanics and quantum field theory there are many examples of theories with global symmetries which are spontaneously broken at zero temperature. Typically, one expects such symmetries to be restored at sufficiently high temperature. The purpose of this paper is to prove the absence of spontaneous symmetry breaking at high temperature in a wide class of theories which includes gauge theories with bosonic matter fields (commonly called Higgs theories).

In the case of abelian Higgs theories, previous work by Kennedy and King [7] proves the existence of a low temperature phase with spontaneously broken global gauge invariance. Combined with our result, this implies that a phase transition must separate the unbroken symmetry high temperature phase from the broken symmetry low temperature phase. To our knowledge, this provides the first rigorous demonstration that the Higgs phenomenon in abelian gauge theories is associated with a genuine finite temperature phase transition.

Our proof of the absence of high temperature symmetry breaking is also applicable to non-abelian Higgs theories, however in such theories there is no corresponding demonstration of the breaking of global gauge symmetry at low temperature. (The abelian proof cannot be generalized to non-abelian theories for several reasons. These include the fact that the order parameter used in abelian theories – essentially equal to the Higgs field in Landau gauge – is not well defined in non-abelian theories. In addition, in some non-abelian theories there are strong

* Research supported in part by U.S. National Science Foundation grant PHY 8117463
** Research supported in part by the Department of Energy under grant No. DE-AC02-76ER03072
*** Alfred P. Sloan Research Fellow