Commun. Math. Phys. 171, 531 – 546 (1995)

Communications in Mathematical Physics

Particle-Field Duality and Form Factors from Vertex Operators

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Received: 21 December 1993/in revised form: 13 June 1994

Abstract: Using a duality between the space of particles and the space of fields, we show how one can compute form factors directly in the space of fields. This introduces the notion of vertex operators, and form factors are vacuum expectation values of such vertex operators in the space of fields. The vertex operators can be constructed explicitly in radial quantization. Furthermore, these vertex operators can be exactly bosonized in momentum space. We develop these ideas by studying the free-fermion point of the sine-Gordon theory, and use this scheme to compute some form-factors of some non-free fields in the sine-Gordon theory. This work further clarifies earlier work of one of the authors, and extends it to include the periodic sector.

1. Introduction

For relativistic quantum field theories with a massive particle spectrum, the main dynamical properties one is interested in are the S-matrix, the form factors of all local fields, and the Green's functions of these fields. For the integrable quantum field theories in 2 space-time dimensions, some of these properties have been computed exactly. The algebraic structures that characterize the S-matrices are well-known [1], and have been used to compute them for a wide variety of models. Bootstrap axioms satisfied by the form factors have been formulated [2, 3]. Important progress in solving the bootstrap for the multiparticle form factors was made by Smirnov [4, 3], where he computed exactly the form factors of certain basic fields, such as the energy-momentum tensor and global conserved currents in the sine-Gordon (SG) model, $SU(N)$ Thirring model, and $O(3)$ non-linear sigma model.

It is of interest to develop a more algebraic framework for the computation of form factors, with the aim of constructing the solutions for the complete set of fields in an efficient manner. A deeper understanding of such algebraic structures is likely to facilitate generalizations to other models, and could lead to some much-needed new approaches to the problem of computing Green's functions. In the works [5, 6, 7] two new approaches to the computation of form factors were proposed. In