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Zero-Mass Infinite Spin Representations of the Poincaré Group and Quantum Field Theory

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Abstract. It is shown that a local quantized field with a manifestly covariant transformation law under the Poincaré group cannot have nonvanishing matrix elements between the vacuum and an irreducible subspace of zero mass and infinite spin.

1. Introduction

The zero-mass infinite spin representations of the Poincaré group $\mathscr{P}_+^\uparrow$ [1–3] do not seem to correspond to anything in nature and have consequently received little attention from physicists. Nevertheless, it might be instructive to know whether these "strange" representations violate some fundamental principle, or if their exclusion from physical theories is an independent postulate. The present paper deals with the question whether they can appear in a local quantum field theory. This seems to be a natural question since at least free fields can be constructed corresponding to any of the other irreducible representations of $\mathscr{P}_+^\uparrow$ that satisfy the spectrum condition [4]. It is however clear, that if we want to extend this construction to the case of infinite spin, we must allow infinite dimensional representations of $SL(2, \mathbb{C})$ in the transformation law of the field. We modify the usual Wightman axioms [5] in accordance with this fact.

It turns out, however, that this modification is not sufficient. The generalized Wightman axioms, especially local commutativity and the local (manifestly covariant) transformation law, will be shown to exclude the "strange" representations in the following sense: The field operators cannot have nonvanishing matrix elements between the vacuum and states that transform according to an irreducible representation of zero mass and infinite spin. In particular, there are no free fields corresponding to these representations.