WARD'S IDENTITIES AND CALCULATION OF MULTILOOP AMPLITUDES IN STRING THEORY

G. S. Danilov

It is well known that boson string theory is invariant under both the group of general two-dimensional reparametrization and the group of Weyl transformations. Accordingly, this theory is a gauge theory where two-dimensional metric plays the role of a gauge field. In this paper /1/ the above mentioned gauge invariance of the string theory is used for the calculation of multiloop amplitudes. In contrast to the well known conformal approach /2/ we use the invariance of string theory under the whole group of two-dimensional reparametrization, but not only under the conformal group (the latter being the subgroup of the group of general two-dimensional reparametrization). As a result we derive a closed system of equations for the calculation of multiloop amplitudes in the string theory.

These equations are the consequences of relations that are analogous to Ward identities in the string theory. Due to the high gauge symmetry of the string, these relations determine actually the whole multiloop amplitude except the factor which depends only on the number of loops.

These equations can be divided into two independent systems. One of these systems allows to determine the vertices in the string theory. The solution of the other system determines the partition function, i. e. the factor in the integral over the moduli of Riemann surfaces, that contains the determinants arising from the integration over both matter and ghost fields, just as the contributions of the zero-modes of the ghosts and the measure moduli space. The solution of the discussed equations is not very difficult and leads to a formula for multiloop amplitude with any number of loops. Since the whole partition function is calculated from equations in one approach, the calculation of both the zero mode contribution and the moduli volume form is free from difficulties common in other known approaches.

The considered approach can be used in the superstring theory as well. At present we have derived and solved equations determining the partition function in the superstring theory of Neveu-Schwartz-Ramon. One of the main difficulties in this theory was that all the previously constructed multiloop amplitudes contained a dependence on the arbitrary choice of gravitino zero modes. The previously used approaches, however, are inconsistent and, in particular, they lead to ambiguity in the measure of integration over supermoduli of supersurfaces /3/.

In contrast to these methods, our approach is consistent and the partition function obtained by us provides for the multiloop amplitude to be independent on choice of a basis for gravitino zero modes. As to the existence of other possible pathologies in the superstring theory, this matter could be cleared up by more detailed analysis of the discussed formula for partition function.

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