RADIATIVE CORRECTIONS TO THE AXIAL ANOMALY

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It has been widely believed for many years that the transition amplitude of the divergence of the axial current $\partial_\mu j^5_\mu$ into two photons is determined solely by the famous triangle diagram (the Adler-Bardeen theorem /1/). In supersymmetric theories this anomaly enters the same supermultiplets as the anomaly in the trace of energy-momentum tensor. The latter is proportional to the β function and, therefore, cannot be restricted to one loop. There have been a number of attempts to resolve this apparent paradox.

In the paper /2/ we show that in any theory — supersymmetric or not — the axial anomaly has multiloop contributions. These corrections are due to diagrams with the scattering of vector particles (photons and gluons); in fact, the evolution of the operators $F_{\mu\gamma}\widetilde{F}_{\mu\gamma}$ (in QED) or $G^a_{\mu\gamma}\widetilde{G}^{\mu\gamma}_a$ (in the Yang-Mills theory) plays a crucial role. In the paper /1/ these diagrams were neglected by dimensional considerations which are not valid for the case of massless fermions.

In fact, there is a distinction between the operator equations for the divergence of the axial anomaly and the equation for the matrix element of the axial current. Really the one-loop form of the operator equation is conventional, it depends on the choice of the regularization of the axial current. For example, in the nonsupersymmetric case the «natural» regularization by Pauli-Willars fermions leads to a one-loop form of the operator equation. However one can show that other regularizations can result in the multiloop form of the operator equation. Such regularizations might seem to be rather unnatural. However in SUSY theories they give the only possibility to put the axial current and the conserved energy-momentum tensor in the same supermultiplet, and, hence, to preserve supersymmetry. In the SUSY case the ambiguity of the operator equation (its one-loop or multiloop form) has been demonstrated before in /3/. In the paper /2/ we show that in terms of renormalized matrix elements the final result is of multiloop form and does not depend on a regularization procedure.

Thus the common belief that the gauge invariance is sufficient to fix unambiguously the axial anomaly is only partly correct. This is true for the renormalized matrix elements while the form of the operator equation is ambiguous.

The distinction between an operator form of the anomaly equation and its matrix form has been understood before as a key point in SUSY theory in ref /4/. Actually the multiloop character of the anomaly has no special connection with SUSY: the 'SUSY' paradox is a particular manifestation of a common situation.

In ref. /2/ we calculate radiative correction in QED and in non-Abelian theories and also show that in SUSY QED these multiloop contributions explain the apparent contradiction between the axial anomaly and the anomaly in the trace of energy momentum tensor. The case of SUSY non-Abelian theories is more complicated because the off-shell matrix elements depend here on the gauge fixing.

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