Regularization of the NJL model free of ambiguities and violations of Ward identities

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Like with most of quantum field theoretical models, ultraviolet divergences occur in the process of calculating physical quantities within the Nambu–Jona-Lasinio (NJL) model and a regularization and renormalization procedure is required to give physical sense to the results. The most commonly regulations schemes used in the NJL model such as three- and four-momentum cutoff, Pauli-Villars and proper-time lead to ambiguities and to symmetry violations. There are ambiguities associated with the arbitrary rotulation of internal line momenta in diverging loop amplitudes which invariably lead to the breaking of space-time homogeneity. Also ambiguities associated with the choice of common scales for the divergent and finite parts of amplitudes may lead to the breaking of scale invariance. In general different sorts of ambiguities have the potential of leading to the violation of symmetry relations of global and local gauge symmetries. Here we apply to the NJL model a novel regularization scheme recently developed [1] that is free of the mentioned ambiguities and symmetry violations. The method has been used to study triangle anomalies [2], extended QED with Chern-Simmons term [3], and to the gauged NJL model [4]. The The basis of this novel method is the assumption of the existence of an implicit Lorentz invariant regulator allowing all manipulations valid for finite integrals. By purely algebraic manipulations of the integrands of the implicitly regulated integrals it is possible to isolate all divergences in amplitudes with integrands that are independent of arbitrary internal routing momenta. Such purely divergent integrals are obtained without explicit evaluation of a single integral. Symmetry violating pieces of the regulation scheme can be eliminated by imposing consistency conditions in such a way that symmetry preserving physical amplitudes are obtained. The consistency conditions allow to identify the reasons the commonly used regulation schemes lead to symmetry violations. Invariably, the reasons are that not all the consistency conditions are satisfied. Phenomenological quantities, such as the constituent quark e pion masses, the pion decay constant and the quark condensate are calculated using this regularization method [5].

References

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