Realistic implementation of massive Yang-Mills theory for \( \rho \) and \( a_1 \) Mesons

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Local gauge theories are a central guiding principle in describing elementary particle interactions. Among its attractive features is the use of a universal gauge coupling constant to characterize the interactions. The massive Yang-Mills approach embodies this principle by implementing axial-/vector mesons into the chiral pion Lagrangian, but in the past it had difficulties in describing experimentally measured spectral functions.

In this work [1] we have advanced the massive Yang-Mills framework for hadronic interactions in vacuum by implementing a dressed \( \rho \)-meson propagator into the self-energy of its chiral partner, the \( a_1(1260) \) meson. The main achievement in this procedure is the preservation of chiral symmetry of the low-energy strong interaction, made possible by an identification of suitable vertex corrections in the pico-rho loop of the \( a_1 \) self-energy while rendering loop integrals finite through suitable counter-terms based on the Lagrangian interactions, see Fig. 1.

![Diagram of corrections](image)

**FIG. 1.** Diagrammatic representation of the corrections to the \( \pi \rho a_1 \) vertex necessary to preserve chiral symmetry when utilizing a fully dressed \( \rho \) propagator in the \( a_1 \) self-energy.

When attempting a fit to the vector and axialvector spectral functions, as accurately measured in hadronic decays of the \( \tau \) lepton [2], the concept of a universal high-energy continuum in both channels [3] has been employed, based on the notion that the effective theory decouples at sufficiently large masses, here somewhat above the \( a_1 \) resonance, \( M > 1.4 \) GeV. Together with the broad rho propagator in the axialvector spectral function, this enabled a fair agreement with experimental data, see Fig. 2.

Our framework re-establishes the local gauge principle as a viable description of axial-/vector mesons in the chiral pion lagrangian. It also provides a realistic basis for future investigations of the long-standing question of chiral symmetry restoration in the context of dilepton data in heavy-ion collisions [4].
FIG. 2. Our fit to the vacuum vector (left) and axial-vector (right) spectral functions as measured in hadronic decays of the $\tau$ lepton [2] into an even or odd number of pions, respectively.