Realistic implementation of massive Yang-Mills theory for ρ 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 ρ-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 pi-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.

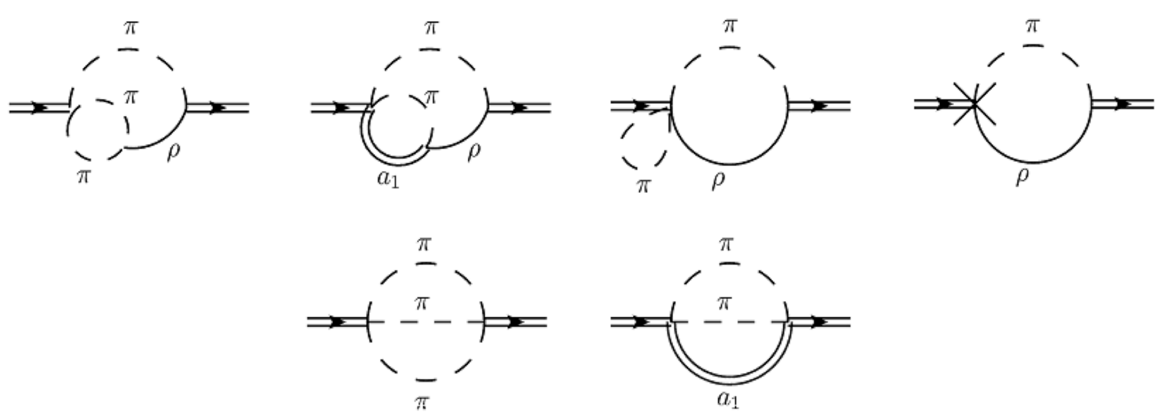

FIG. 1. Diagrammatic representation of the corrections to the $\pi\rho a_1$ vertex necessary to preserve chiral symmetry when utilizing a fully dressed ρ propagator in the a_1 selfenergy.

When attempting a fit to the vector and axialvector spectral functions, as accurately measured in hadronic decays of the τ 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].

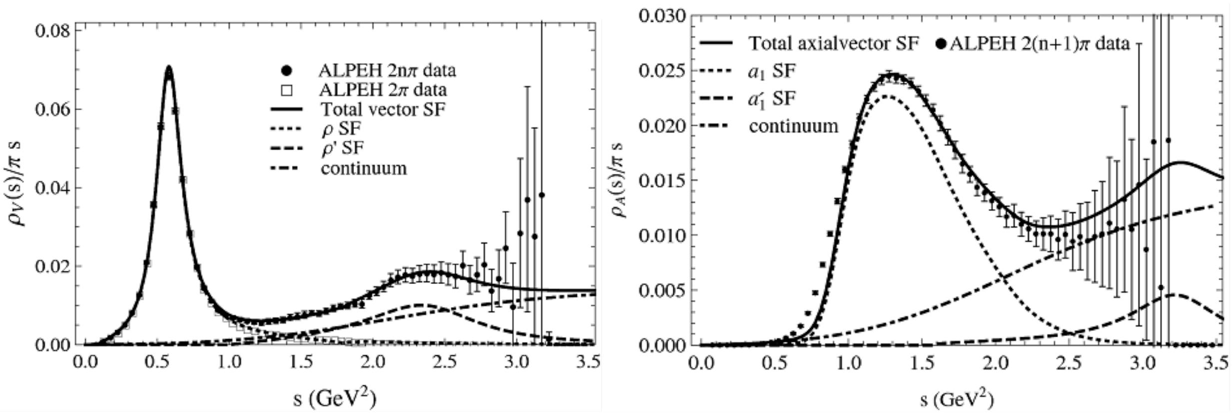

FIG. 2. Our fit to the vacuum vector (left) and axial-vector (right) spectral functions as measured in hadronic decays of the τ lepton [2] into an even or odd number of pions, respectively.

[1] P.M. Hohler and R. Rapp, Phys. Rev. D **89**, 125013 (2014)

[2] R. Barate *et al.* (ALPEH Collaboration), Eur. Phys. J. C **4**, 409 (1998); K. Ackerstaff *et al.* (OPAL Collaboration), Eur. Phys. J. C **7**, 571 (1999).

[3] P.M. Hohler and R. Rapp, Nucl Phys. **A892**, 58 (2012).

[4] R. Rapp, J. Wambach, and H. van Hees, in *Relativistic Heavy-Ion Physis (R. Stock, ed.)*, Landolt-Börnstein (Springer) **23**, 134 (2010) [e-print arXiv:0901.3289 [hep-ph]].