Chiral Partners in a Chirally Broken World

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The isovector–vector and the isovector–axial-vector current are related by a chiral transformation. These currents can be called chiral partners on the fundamental level. In a world where chiral symmetry was not broken, the corresponding current-current correlators would show the same spectral information. In the real world chiral symmetry is spontaneously broken. A prominent peak — the ρ-meson — shows up in the vector spectrum (measured in e^+e^--collisions and τ-decays). On the other hand, in the axial-vector spectrum a broad bump appears — the a_1-meson (also accessible in τ-decays). It is tempting to call ρ and a_1 chiral partners on the hadronic level. Strong indications are brought forward that these "chiral partners" do not only differ in mass but even in their nature: The ρ-meson appears dominantly as a quark-antiquark state with small modifications from an attractive pion-pion interaction. The a_1-meson, on the other hand, can be understood as a meson-molecule state [1,2] mainly formed by the attractive interaction between pion and ρ-meson. A key issue here is that the meson-meson interactions are fixed by chiral symmetry breaking. It is demonstrated that one can understand the vector and the axial-vector spectrum very well within this interpretation. It is also shown that the opposite cases, namely ρ as a pion-pion molecule or a_1 as a quark-antiquark state lead to less satisfying results. Finally speculations on the nature of other hadron states and on possible in-medium changes of hadron properties are presented.

[1] M. Wagner and S. Leupold, arXiv:0708.2223 [hep-ph]
[2] M. Wagner and S. Leupold, arXiv:0801.0814 [hep-ph]

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