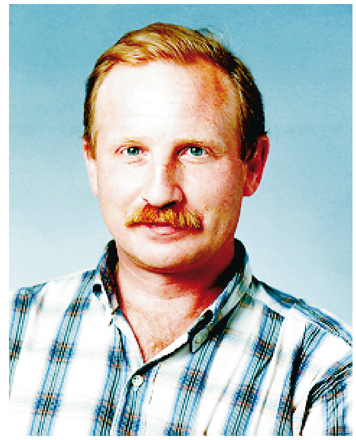
QCD SUM RULES AND HADRONIC RADIAL EXCITATIONS OF LIGHT MESONS



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Extended Absrtact

It is well known that the QCD sum rules method was formulated in its classical form in Ref.[1], where it was proposed to relate the properties of the ground states of hadrons to the number of the nonperturbative fundamental QCD parameters, namely quark and gluon condensates $<\overline{\psi}\psi>$, $<\alpha_s G^2_{\mu\nu}>$, using the operator product expansion method and the realization of the global duality hypothesis, implemented through the Borel-type dispersion sum rules. However, the application of the procedure of the Borelezation can lead to the suppression of the radial excitations of hadronic ground states contributing to the physical spectral density of sum rules.

In this talk we remind that it is possible to study the properties of these radial excitations using the finite-energy QCD sum rules [2], which is the QCD generalization of the method of the dual sum rules, formulated in Ref.[3] to relate high-energy Redge behavior of the hadron-hadron cross-sections with the characteristics of low-lying resonances. This approach, developed in Ref.[4] for the case of ρ, ϕ, J/Ψ and Υ channels, was further used for the estimation of the properties of radial excitations of π-meson in Ref.[5] and K-meson in Ref.[6], where the predictions for the masses and leptonic decay constants of the radial excitations of the light scalar mesons $a_0(980)$, and $K^*_0(1430)$ were also obtained in the cases when both $K^*_0(1430)$ and $a_0(980)$-mesons were considered as the quark-antiquark bound states.

It is stressed that in the ρ-meson channel the derived in Ref.[4] predictions

$$m^2_\rho(n) = m^2_\rho \times (1+2n) \quad , \quad \Gamma_n^{e^+e^-} = \frac{\alpha^2 m^2_\rho}{3\pi(2n+1)} \tag{1}$$

gave one of the first arguments in favor of the fact that the particle $\rho(1700)$ should be considered as the **second** radial excitation of of ρ-meson and that its **first** radial excitation should have the mass of over 1300 MeV. This prediction is now confirmed at CERN by the Crystal Barrel Collaboration through the observation of the first

radial excitation of ρ-meson with the mass $m_{\rho'} = 1411 \pm 10$ $(stat) \pm$ 10 $syst$ MeV in the reaction $\overline{p}n \to \pi^-\pi^0\pi^0$ at LEAR [7].

In the case of π- and K-meson channels the chiral limit FESR prediction is [5]

$$m^2_{PS}(n) = m^2_{PS'} \times n \quad , \quad f_{PS}(n) = 2\sqrt{2}\Big(\frac{m^2_{PS}}{m_{PS'}m_{PS}(n)}\Big)f_{PS} \qquad (2)$$

where $n \geq 1$, PS means the abbreviation for the pseudoscalar mesons π and K and $m_{\pi'} \approx 1.24$ GeV was measured some time ago at Protvino [8]. The following from Eq.(2) prediction $m_\pi(2) \approx 1.75$ GeV is in good agreement with the observation of another $I^GJ^PL = 1^-0^-S$ resonance at 1.77 ± 0.03 GeV [8] which could correspond to a second radial excitation of the pion π''. This experimental result was confirmed recently also at Protvino by VES Collaboration [9]. It should be mentioned, however, that the experimental data of the VES collaboration do not exclude the possibility that the corresponding resonance with the mass $M = 1786 \pm 7(stat) \pm 30(syst)$ MeV has exotic (hybrid-like) nature. In view of this it can be of real interest to study carefully the enhancement in the $\rho\pi$-channel of the system $\pi^+\pi^-\pi^-$ near the invariant mass of order $2.1 - 2.4$ GeV (see Fig. 1. (c) of Ref.[9]), where due to the FESR prediction of Ref.[5] the third radial excitation π''' of the π-meson can manifest itself.

In the scalar channel the predictions of the FESR read [6]

$$m^2_S(n) = m^2_S \times (n+1) \quad , \quad f^2_S(n) = \frac{1}{n+1}f^2_S \quad . \qquad (3)$$

The strange candidate to the scalar (S) ground state is the $K^*(1430)$-meson. In view of the predictions of Eq.(3) it is reasonable to expect, that its first radial excitation can have the mass of over 2 GeV. This expectation is in good agreement with the experimental indications to the existence of its first radial excitation, namely $K^*(1950)$-meson [10].

The situation in the non-strange scalar sector is more intriguing. Despite the fact that there are the studies of the possibilities that the lightest non-strange scalar meson $a_0(980)$ can be the four-quark state or the $\overline{K}K$-molecule (see e.g. Ref.[11]), there are also the arguments in favor of the standard $\overline{q}q$-structure of the $a_0(980)$-meson (for one of the latest related works see Ref. [12]). The FESR considerations of Ref.[6], which were made in this case, are giving the predictions of the mass of radial excitation of the $a_0(980)$-meson, namely $m_{a'_0} \approx 1.4$ GeV [6]. It is interesting to note that not long ago the Crystal Barrel Collaboration at CERN have found the signal of the non-strange scalar particle $a_0(1450)$ in the reaction $\overline{p}p \to \pi^0\pi^0\eta$ [13].

It is also worth to add several words about one more QCD sum rules predictable characteristic of light mesons, which is directly related to the experimental data, obtained at Protvino. This characteristic is the ratio $\gamma = F_A/F_V$ of the axial and vector form-factors of radiative decay of charged pseudoscalar meson $\pi^+ \to e^+\nu\gamma$, which provides the important information about the structure of weak hadronic currents (for the review see Ref.[14]). The application of the three-point function

QCD sum rules and of the generalized operator product expansion, formulated in the works of Ref.[15], resulted in the following value of this parameter [16]:

$$\gamma = 0.51 \pm 0.13 \quad (theory,\ QCD\ sum\ rules)\ . \tag{4}$$

It is in perfect agreement with the outcome of the latest most precise measurement of this parameter, obtained by the Istra collaboration at the Protvino accelerator [17]:

$$\gamma = 0.41 \pm 0.23 \quad (experiment)\ . \tag{5}$$

This note is prepared within the framework of the program of the research of the Project №96-01-01860 of the Russian Fund for Fundamental Research.

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