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ON POSSIBILITY OF OBTAINING OF MORE RELIABLE EXPERIMENTAL VALUE OF $\rho \to \pi\gamma$ RADIATIVE DECAY WIDTH

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ON POSSIBILITY OF OBTAINING OF MORE RELIABLE EXPERIMENTAL VALUE OF $\rho \to \pi\gamma$ RADIATIVE DECAY WIDTH

Yerevan 1980

Obtaining of more reliable experimental value of the $\rho \to \pi\gamma$ decay width is important for many problems of the SU(3)-symmetry and the quark model. Here belong finding out of the SU(3)-symmetry violation scheme (see, e.g. [1-3]), clearing up the existence of quark anomalous magnetic moments [4,5] and extraction of more precise value of u- and d-quarks mass ratio and the isotopic invariance violation [6].

The $\rho \to \pi\gamma$ decay width is obtained indirectly from experiments on ρ^- -meson coherent production in the reaction $\pi^- A \to \rho^- A$ using the Primakoff effect. The experiments at the energies of 22.7 GeV ($\Gamma(\rho \to \pi\gamma) = 35 \pm 10$ KeV) [7] and 150 GeV ($\Gamma(\rho \to \pi\gamma) = 49 \pm 10$ KeV) [8] are carried out. The values of $\Gamma(\rho \to \pi\gamma)$ obtained in the both experiments are small as compared with the value of $\Gamma(\omega \to \pi\gamma)/9 = 97 \pm 6$ KeV which is predicted in the non-violated SU(3)-symmetry and in the quark models that do not take into account the anomalous magnetic moments of quarks and difference between u- and d-quark masses. The extraction of value of $\Gamma(\rho \to \pi\gamma)$ in these experiments is connected with different kinds of difficulties. In the experiment at low energies [7] the difficulties are due to the large contribution of strong interaction. At high energies this contribution is insignificant due to strong growth of the Coulomb peak ($\sim E^{3}_{lab}$), but there are difficulties connected with decrease of the angle θ^{max}_{lab} to which the maximum Coulomb cross section corresponds ($\theta^{max}_{lab} \sim E^{-\frac{3}{2}}_{lab}$).

In the experiment at 22.7 GeV [7] , in order to extract the effects connected with strong interaction, the measurements on nuclei with different atomic numbers from C to U are carried out. The Coulomb contribution to the amplitude of ρ -meson coherent production slightly depends on the absorption effects in the nucleus, and with increasing of the atomic number (A) its dependence on Z slightly differs from the linear one. The amplitudes that correspond to strong interaction are heavily suppressed by the absorption effects and grow much more slower as A increases.

In Ref. [7] , when obtaining final results an additional assumption is made that the amplitude of ρ -meson production on separate nucleons ($\pi^- N \to \rho^- N$), which corresponds to strong interaction, is dominated by the isoscalar ω -exchange. As a result, it turned out that the strong interaction contribution to the amplitude of coherent production for $\pi^- A \to \rho^- A$ is fixed by the experiments on nuclei with small A(C, Al), whose Coulomb peak is negligibly small. Then the experiments on nuclei with large A(Cu, Ag, Pb, U) permit to determine the Coulomb amplitude. The experimental value of Γ ($\rho \to \pi\gamma$)= = 35±10 KeV is obtained in [7] under these assumptions from the joint analysis of data on C, Al, Cu, Ag, Pb, U. Thus, when obtaining this experimental value the possible effects due to isovector exchanges in $\pi^- N \to \rho^- N$, in particular, with A_2 -exchange [9], are not taken into account. The relative contribution of the isovector amplitude, as compared with the isoscalar one, to the amplitude of coherent production on nuclei, is determined by the value $\delta = \delta_1 \cdot \delta_2$. where δ_1 is the ratio of these amplitudes in $\pi^- p \to \rho^- p$, $\delta_2 = \frac{Z-N}{Z+N}$ (N is the number of neutrons in nucleus). The quantity δ_2 is equal to zero for C and Al, and for Cu, Ag, Pb and U it is equal to 0.09, 0.13, 0.21 and 0.23, respectively. Thus the isovector amplitude contribution becomes larger as the atomic number increases, and if the quantity δ_1 is not small, this contribution can influence substantially the estimate $\Gamma(\rho \to \pi\gamma)$.

Consider now the presented in [7] results of different variants of the analysis with various phases φ between the Coulomb amplitude and the one corresponding to the strong interaction. If taking away the unsatisfactory over χ^2 values results of the analysis at $\varphi = 180^0$, then from the rest variants of the analysis a relatively large quantity $\Gamma(\rho \to \pi\gamma)$ is obtained at $\varphi = 90^0$. Here the modulus of the amplitude Co which is interpreted in [7] as corresponding to strong production on a nucleon is falling as the atomic number grows (Co for C and Al is more than twice as large than for Pb and U). Such a behaviour of Co can be explained only by essential contribution of isovector exchanges. To estimate such contributions in the amplitude $M_{1\frac{1}{2}\frac{1}{2}}(\pi^- p \to \rho^- p)$, determining the amplitude of the ρ^- -meson coherent production in the reaction $\pi^- A \to \rho^- A$, different models are necessary.

We have estimated contributions corresponding to A_2- and $\pi\rho$ - exchanges. Using the approach developed in [10] for A_2-exchange we have obtained

$$|\delta_1^{A_2}| \equiv \frac{|M^{A_2}_{1\frac{1}{2}\frac{1}{2}}|}{|M^{\omega}_{1\frac{1}{2}\frac{1}{2}}|} = \frac{G_V^{A_2}}{G_V^{\omega}} \quad \frac{G(A_2 \to \rho\pi)}{G(\omega \to \rho\pi)}, \qquad (1)$$

where the amplitudes $G_V^{A_2}$ and G_V^{ω} are defined in [10] and are coupled with the pp -scattering amplitudes by the relation

$$\frac{|M^{A_2}_{\frac{1}{2}\frac{1}{2}\frac{1}{2}\frac{1}{2}}(pp \to pp)|}{|M^{\omega}_{\frac{1}{2}\frac{1}{2}\frac{1}{2}\frac{1}{2}}(pp \to pp)|} = \left| \frac{G_V^{A_2}}{G_V^{\omega}} \right|^2, \qquad (2)$$

the amplitudes $G(A_2 \to \rho\pi)$ and $G(\omega \to \rho\pi)$ are determined by the decay widths $\Gamma(A_2 \to \rho\pi)$ and $\Gamma(\omega \to \pi\gamma)$.

$$\Gamma(A_2 \to \rho\pi) = \frac{|G(A_2 \to \rho\pi)|^2}{10\pi S_0} K^5, \qquad (3)$$

$$\Gamma(\omega \to \pi\gamma) = \frac{|G(\omega \to \pi\rho)|^2}{12\pi S_0} \frac{e^2}{4\gamma_\rho^2} q^3, \qquad (4)$$

$S_0 = 1 GeV^2$, $\frac{e}{4\pi} = \frac{1}{137}$, $\frac{\gamma_\rho^2}{4\pi} = 0.53 \pm 0.10$ is the vector dominance constant, K and q are the c.m.s. pion momenta in the decays $A_2 \to \rho\pi$ and $\omega \to \pi\gamma$, respectively. Using the experimental data for $\Gamma(A_2 \to \rho\pi)$ and $\Gamma(\omega \to \pi\gamma)$

as well as the values of G_V^{ω} and $G_V^{A_2}$ from [10] we obtain:

$$\left| \delta_1^{A_2} \right| = 0{,}62 \,, \qquad (5)$$

which is 2.4 times less than that obtained in [9] from the same data. If using the values of G_V^{ω} and $G_V^{A_2}$ from the other works (e.g. [11]), then for $/ \delta_1^{A_2} /$ the smaller values are obtained. Note also, that the information on the A_2 -exchange contribution to $M_{1\frac{1}{2}\frac{1}{2}}(\pi^- p \to \rho^- p)$ may be extracted from the $\gamma N \to \pi N$ reaction analysis. The latter gives for the quantity $/ \delta_1^{A_2} /$ the values which are smaller than in (5) (see, e.g. [12]).

The contribution of πP -cut in $M_{1\frac{1}{2}\frac{1}{2}}(\pi^- p \to \rho^- p)$ is to a high extent model-dependent. It is determined by the radii of pion and pomeron exchanges and the pomeron-nucleon-nucleon spin-flip vertex ($M^P_{\frac{1}{2}-\frac{1}{2}}$) which is scarcely known. If the contribution of this vertex, as compared with that of spin-non-flip ($M^P_{\frac{1}{2}\frac{1}{2}}$), is 5%, then a relative contribution of the πP -cut in the amplitude $M_{1\frac{1}{2}\frac{1}{2}}(\pi^- p \to \rho^- p)$ is as follows

$$\left| \delta_1^{\pi P} \right| \equiv \frac{\left| M^{\pi P}_{1\frac{1}{2}\frac{1}{2}} \right|}{\left| M^{\omega}_{1\frac{1}{2}\frac{1}{2}} \right|} < 0.1 \,. \qquad (6)$$

The quantity $/ \delta_1^{\pi P} /$ increases as the ratio $\frac{M^P_{\frac{1}{2}-\frac{1}{2}}}{M^P_{\frac{1}{2}\frac{1}{2}}}$ grows.

Thus we have not obtained a sufficiently large isovector contribution in $M_{1\frac{1}{2}\frac{1}{2}}(\pi^- p \to \rho^- p)$ to explain the variant of the analysis with $\varphi \approx 90^{\circ}$. However the estimates performed are model-dependent, and there is no possibility to isolate without models the isovector contribution in the amplitude $M_{1\frac{1}{2}\frac{1}{2}}$ in the reaction on proton $\pi^- p \to \rho^- p$. Besides, the relative phases of contributions of isovector and isoscalar exchanges in this amplitude are insufficiently known.

To our mind, the data on the reaction $\pi^- A \to \rho^- A$ at 22.7 GeV [7] are not sufficient to obtain the model-independent estimate of $\Gamma(\rho \to \pi\gamma)$. In order to obtain a doubtless estimate of $\Gamma(\rho \to \pi\gamma)$ from experiments at low energies the analogous experiment on $\pi^+ A \to \rho^+ A$ on nuclei with different atomic numbers is necessary. If the role of isovector contributions is essential, then the integrated total cross sections of $\pi^\pm A \to \rho^\pm A$ will have different dependences on A. If the variant of the analysis with $\varphi = 90^\circ$ in [7] is true, then in contrast with the experiment on $\pi^- A \to \rho^- A$ in the experiment on $\pi^+ A \to \rho^+ A$ the modulus of amplitude Co corresponding to strong production on a nucleon will grow as the atomic number increases. A joint analysis of data on $\pi^- A \to \rho^- A$ and $\pi^+ A \to \rho^+ A$ will allow to isolate unambiguously the isovector exchange contribution and obtain a model-independent estimate of $\Gamma(\rho \to \pi\gamma)$.

Note, that we cannot propose the analogous experiment to obtain more precise experimental values of decay widths $K^{*0,+} \to K^{0,+}\gamma$, since, contrary to the decay $\rho \to \pi\gamma$ to which only the isoscalar photon contributes, these decays are determined by contributions of isoscalar and isovector photons.

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И.Г.АЗНАУРЯН, А.С.БАГДАСАРЯН

О ВОЗМОЖНОСТИ УТОЧНЕНИЯ ЭКСПЕРИМЕНТАЛЬНОГО ЗНАЧЕНИЯ ШИРИНЫ РАДИАЦИОННОГО РАСПАДА $\rho \to \pi\gamma$.

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