Role of heavy vector mesons in hadronic photoabsorption

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Allowance for the ψ particles improves the agreement between experiment and the prediction of the vector-dominance model for hadronic absorption of photons. An estimate is obtained of the total cross section for the interaction of hypothetical D particles with nucleons.

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The recently discovered[1] heavy particles $\psi_1(3095)$, $\psi_2(3685)$, and $\psi_3(4150)$ evidently belong to the class of strongly interacting particles and are vector mesons. In this case they influence the total cross section $\sigma_t(\gamma p)$ for the hadronic absorption of photons by protons.

It is known[2] that the contribution of the vector mesons ρ^0, ω, and ϕ to the relation obtained within the framework of the vector-dramework of the vector-dominance model

$$\sigma_t(\gamma p) = \alpha \sum_V \frac{1}{g_V^2/4\pi} \sigma_t(Vp) \qquad (1)$$

(here $\alpha^{-1} \approx 137$, the constant g_V characterizes the coupling of the vector meson V with the photon, and $\sigma_t(Vp)$ is the total cross section for the interaction between the vector meson and the proton) amounts to only 80% of the measured cross section. The meson $\rho'(1600)$ introduces approximately an additional 10%.[3] The remaining discrepancy between the left-hand and right-hand sides of (1), which amounts to ~10 μb, can be attributed to the contribution of the heavy vector mesons. Then, using the values of the constants $g_{\psi_1}^2/4\pi = 10$, $g_{\psi_2}^2/4\pi = 22$, and $g_{\psi_3}^2/4\pi = 17$, obtained from the widths of the ψ-particle decays into e^+e^- pairs, we get the following restriction on the total cross sections of the ψp interaction:

$$\sigma_t(\psi p) < 7 \text{ mb}. \qquad (2)$$

We have put here $\sigma_t(\psi_1 p) \approx \sigma_t(\psi_2 p) \approx \sigma_t(\psi_3 p)$, in ac-

cordance with the hypothesis that the ψ particles constitute bound states of a quark and antiquark, and have the new quantum number charm (see e.g.,[4]). Within the framework of the additive quark model, we can write down the relation between the total cross sections for the interaction of protons with ψ particles, pions, and hypothetical charmed particles D

$$\sigma_t(\psi p) = \sigma_t(\bar{D}^0 p) + \sigma_t(D^0 p) - \sigma_t(\pi^+ p), \tag{3}$$

which enables us, using (2) and the data on πp scattering, to estimate $\sigma_t(Dp)$ at high energies, where $\sigma_t(D^0 p) \approx \sigma_t(\bar{D}^0 p)$:

$$12 \text{ mb} < \sigma_t(Dp) < 15 \text{ mb}. \tag{4}$$

The upper limit (2) exceeds the value of $\sigma_t(\psi p)$ obtained from the data on the photoproduction of ψ particles,[5] a fact that may point to the existence of other vector mesons. The small value of $\sigma_t(\psi p)$ in comparison with the cross sections for the usual hadrons will lead to weak shadow effects in the rescattering of ψ particles in nuclei, and also to a smaller value of the diffraction-peak slope parameter $b[d\sigma/dt = A \exp(-b|t|)]$ in ψp scattering, namely $b < 2$ (GeV/c)$^{-2}$. This will affect, in particular, the increase of the fraction of the diffraction photoproduction of ψ particles with large momentum transfers relative to photoproduction of a vector meson (ρ^0, ω, and ϕ).

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