Comment on the Magnetic Dipole Decays of Mesons

Nathan Isgur
Department of Physics, University of Toronto, Toronto, Ontario, Canada

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It is shown that a realistic quark model is consistent with current experimental evidence on the magnetic dipole decays of the vector and pseudoscalar mesons.

There has been some discussion lately[1,2] concerning the magnetic dipole decays of the low-lying mesons, and in particular a seeming discrepancy with the predictions of the quark model.[3] It is the purpose of this note to point out that, at least if the conclusions of one experiment are relaxed,[4] the quark model *can* successfully describe these decays. Since the situation is very straightforward, my comments will be very brief.

My assumptions are these: (1) The quark magnetic moments μ_u, μ_d, and μ_s are the same as those which determine the baryon magnetic moments; (2) since the spin-dependent forces are strong, the overlap integrals $I_{P_jV_i} \equiv \int d^3r\, \Psi_{P_j}{}^* \Psi_{V_i}$ are not equal to 1 (but are more or less independent of i and j); and (3) the pseudoscalar- and vector-meson mixing angles are $\theta_P = -10° \pm 1°$ and $\theta_V = 39° \pm 1°$ as given by the quadratic mass formula.

From the magnetic moments of the proton, neutron, and Λ one can conclude that $\mu_u \simeq \frac{2}{3}\mu_p$, $\mu_d \simeq -\frac{1}{3}\mu_p$, and $\mu_s = -\frac{1}{3}x\mu_p$, where $x \simeq 0.7$. The only free parameter in this approach is therefore $|I_{PV}|^2$ which is taken to be 0.6 ± 0.1. This value, chosen to fit the data, is typical of nonrelativistic quark models; the indicated uncertainty represents a guess as to the size of the (presently unpredictable) fluctuations in $I_{P_jV_i}$ as a function of i and j.

The results are displayed in Table I, where

TABLE I. Magnetic dipole decays of the vector and pseudoscalar mesons.

Decay	$\dfrac{\mu_{PV}}{\mu_p\, I_{PV}}$	Theory[a] (keV)	Experiment (keV)
$\rho\to\pi\gamma$	$\frac{1}{3}$	75±12	55±25 [b]
$\rho\to\eta\gamma$	$\sin\phi_P$	46±7	<160 [c]
$\eta'\to\rho\gamma$	$\cos\phi_P$	95±16	<270 [d]
$\omega\to\pi\gamma$	$\cos\phi_V$	720±120	870±80 [d]
$\omega\to\eta\gamma$	$\frac{1}{3}\cos\phi_V\sin\phi_P+\frac{2x}{3}\sin\phi_V\cos\phi_P$	4.9±0.8	<50 [d]
$\eta'\to\omega\gamma$	$\frac{1}{3}\cos\phi_V\cos\phi_P-\frac{2x}{3}\sin\phi_V\sin\phi_P$	10±2	<50 [e]
$\phi\to\pi\gamma$	$\sin\phi_V$	6.9±4.0	5.9±2.1 [f]
$\phi\to\eta\gamma$	$\frac{1}{3}\sin\phi_V\sin\phi_P-\frac{2x}{3}\cos\phi_V\cos\phi_P$	70±17	65±15 [f]
$\phi\to\eta'\gamma$	$\frac{1}{3}\sin\phi_V\cos\phi_P+\frac{2x}{3}\cos\phi_V\sin\phi_P$	0.27±0.06	---
$K^{*0}\to K^0\gamma$	$-\frac{2}{3}(\frac{1+x}{2})$	120±25	75±35 [g]
$K^{*+}\to K^+\gamma$	$\frac{1}{3}(2-x)$	75±17	<80 [d]

[a] $\Gamma(V\to P\gamma) = \frac{4}{3}\alpha\mu_{PV}{}^2\omega^3$, $\Gamma(P\to V\gamma) = 4\alpha\mu_{PV}{}^2\omega^3$.
[b] See Ref. 4; this is not the value quoted by the authors.
[c] Ref. 5.
[d] Ref. 6.
[e] Ref. 7.
[f] Ref. 8.
[g] Ref. 9.

for convenience I have defined $\varphi_{P(V)} \equiv \theta_{P(V)} - \arctan 1/\sqrt{2}$. The errors in theory are those generated by the uncertainties in $I_{P_j V_i}$, φ_P, and φ_V and demonstrate that current experimental evidence is consistent with the quark-model predictions to an accuracy one might realistically anticipate. The data also confirm $x \simeq 0.7$ as derived from the baryon magnetic moments and expected in some models with confined pointlike quarks.

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[4] B. Gobbi *et al.*, Phys. Rev. Lett. 33, 1450 (1974). In this article the limit 30±10 keV$\leq \Gamma(\rho \rightarrow \pi\gamma) \leq$ 80±10 keV is set in a straightforward fashion. The authors then go on to argue in model-dependent terms that $\Gamma(\rho \rightarrow \pi\gamma)$ =35±10 keV. We shall here take $\Gamma(\rho \rightarrow \pi\gamma)$ =55±25 keV in accordance with their stronger conclusion. Such a relaxation of the findings of this experiment was also suggested by the authors of Refs. 1 and 2.

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Comment on Hadronic Production of Psions

S. D. Ellis
University of Washington, Seattle, Washington 98195*

and

Martin B. Einhorn and C. Quigg†
Fermi National Accelerator Laboratory,‡ Batavia, Illinois 60510

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We discuss a scheme for understanding the observed features of new-particle production. Qualitative tests of the conjectured mechanism are outlined, and the experimental data are reviewed.

In this note we draw attention to a possible mechanism for hadronic production of $J/\psi(3095)$ and related resonances which appear to integrate many experimental observations. We propose that the $J/\psi(3095)$ is, to an excellent approximation, not produced directly in hadron-hadron collisions, but arises from decays of psions with even charge conjugation. Although this mechanism has been mentioned in passing before,[1] recent experimental developments encourage us to present an explicit exposition.

We regard the psions as "hidden new quantum number" states of a massive quark-antiquark pair. For present purposes it is unnecessary to specify the new quantum number carried by the heavy quark which is responsible for the metastability of the psions. Nevertheless it will be convenient to yield to prejudice and designate the new quark as the charmed quark c. The inhibition of the decay of a $c\bar{c}$ bound state into uncharmed hadrons is interpreted as a consequence of the phenomenological Okubo-Zweig-Iizuka (OZI) rule.[2] From the perspective of quantum chromodynamics, circumvention of the OZI rule proceeds by the annihilation of the $c\bar{c}$ pair into gluons which in turn communicate with ordinary hadrons. The notion of asymptotic freedom suggests that the effective coupling constant for the annihilation process is small. On the basis of these ideas and of the analogy with the decays of orthopositronium ($^3S_1$) into three photons and of parapositronium ($^1S_0$) into two photons, Appelquist and Politzer[3] anticipated that even-charge-conjugation ($C=+1$) psions should couple to hadrons much more strongly than do odd-charge-conjugation psions. For example, they predicted a width into hadrons for the 1^1S_0 paracharmonium state approximately 75 times the hadronic width of the 1^3S_1 (3095) orthocharmonium state. The 1^1S_0 state has not yet been established (it may be indicated[4] at 2800 MeV/c^2) so a specific test of these gluon-counting arguments is lacking. How-