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Schwinger's phenomenological and dyon descriptions for the new particles

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A phenomenological description proposed by Schwinger to avoid $\Delta Y = 1$ neutral currents predicted particles much akin to the J/ψ variety prior to their experimental recognition. When supplemented with a hypothetical magnetic-dyon model of matter, a natural setting is provided for the newly discovered ψ particles. We extend Schwinger's earlier suggestions to cover more recently discovered states (D, D^*, F, F^*, Υ) and their baryon analogs, using the magnetic-U-spin approach. A key test which differentiates the present description from charm theory is the existence of a relatively narrow $I = 1$, $J^{PC} = 1^{--}$ ψ'' nearly mass degenerate with the established $\psi'(3.684)$. Could it be the recently discovered state $\psi''(3.772)$?

I. INTRODUCTION

Stimulated by the recent plethora of experimentally discovered new particles, quantum chromodynamics and weak-electromagnetic gauge theories have of late received a great deal of attention. However, it remains of the utmost importance to continue the search for alternatives to gauge theories—if only to reassure ourselves that we are on the correct track through the lack of a satisfactory alternative after much study. Bjorken[1] examined the subjective and objective evidence for quantum chromodynamics and weak-electromagnetic gauge theories and proposed an alternative phenomenological (but necessarily nonrenormalizable) approach which appears to reproduce the presently known data. However, the approach keeps intact such concepts as the charm- (Glashow-Iliopoulos-Maiani) mechanism[2] and the question has been raised[3] whether it is meaningful to incorporate these concepts in an alternative *theory*, unless one knows in principle how to control higher-order corrections, e.g., in renormalizable gauge theories. Here we comment on a phenomenological description proposed by Schwinger[4] on how to avoid $\Delta Y = 1$ neutral currents, which at least formally dispenses with the charm-GIM mechanism. Such a description predicted particles much akin to the J/ψ variety prior to their experimental recognition[5] and when supplemented with a hypothetical magnetic-dyon model of matter,[6] provides a natural setting for the newly discovered ψ particles. We extend Schwinger's earlier suggestions to cover more recently discovered states $(D, D^*, F, F^*, \Upsilon)$ and their baryon analogs, using the magnetic-U-spin approach. A key test which differentiates the present description from charm theory is the existence of a relatively narrow $I = 1$, $J^{PC} = 1^{--}$ ψ'' nearly mass degenerate with the long established $\psi'(3.684)$, and we speculate on whether this predicted state could be the recently discovered $\psi''(3.772)$; other predictions are delineated in the text. It is clear that partly because of the phenomenological orientation of our (conservative?) attempt, we are not in a position at this stage to address ourselves to all the issues pertaining to this general area, e.g., the structure of the lepton spectrum or the detailed fitting of neutrino neutral-current data. However, we are aware of phenomenological alternatives to charm gauge models, which give, for instance, a not inadequate description of neutral-current data.[7]

The Schwinger phenomenological approach[4,5] describes a family of unit-spin particles which have normal electromagnetic couplings but much attenuated "strong" couplings to hadrons in a unified description of electromagnetic and weak interactions, one that was designed to account for the empirical absence of $\Delta Y = 1$ neutral currents by abandoning the Cabibbo rotation that creates the theoretical problem. It was replaced by a mixing between two types of unit-spin mesons that is produced by the SU(3)-symmetry-breaking interaction, combined with the hypothesis that the second primed set is only "weakly" coupled to the familiar low-lying hadrons. One consequence of this interpretation is the anticipated existence of *long-lived* counterparts of the (ρ^0, ω, ϕ) of the first set. Since the $\psi(3.095)$ is predominantly an SU(3) singlet[8] while the decay $\psi'(3.684) \to \psi(3.095) + \eta^0$ is rather large [as is consistent with $\psi'(3.684)$ assigned predominantly to an SU(3) octet], it seems reasonable that they correspond to the ϕ and ω, respectively (note that the Schwinger notions have little to say about the *relative* position of singlet and octet among the primed and unprimed sets). In the usual classification, the ρ^0, ω near mass degeneracy is understood by assigning them to SU(2) [while ϕ to U(1)] subgroups of the U_3 symmetry. Hence it is reasonable to expect the $I = 1$ ψ'' partner of $\psi(3.684)$ to be in the vicinity of 3.7 GeV. Again the picture raises, but does not settle, the interesting question of whether all of the hadronic decays of the psion can be attributed to electromagnetic mixing. Nothing in the original conception excludes a residual hadronic coupling. But, even then, there is the possibility that such coupling could be an indirect consequence of electromagnetic interaction.[6] Partners of the psion with $J^P=0^{\pm}$, 1^+, etc., can, of course, be accommodated in this picture. Finally, we are aware[9] that in line with this orientation, a prescription exists for understanding the $R((e^+e^-\to \text{hadrons})/(e^+e^-\to\mu^+\mu^-))$ ratio vs $E_{\text{c.m.}}$ in terms of just one parameter—the ρ mass.

II. THE DYON MODEL OF HADRONIC MATTER

However, phenomenology is not enough; a speculative model is considered superior or at least more interesting[6]; hence we combine this description with the dyon model based on a predominantly electromagnetic picture of the subnucleonic world. The dyon model is based upon the concept of symmetry between electric and magnetic fields as embodied in certain hypothetical spin-$\frac{1}{2}$ Fermi-Dirac particles, called dyons, that carry both electric and magnetic charge. These charges independently occur as fractional multiples $\frac{2}{3}$, $-\frac{1}{3}$, $-\frac{1}{3}$ of the corresponding units of pure charge. All hadrons thus far known are considered to be magnetically neutral composites of dyons. The neutral combination of three dyons, with the respective magnetic charges $\frac{2}{3}$, $-\frac{1}{3}$, $-\frac{1}{3}$, is a Fermi-Dirac particle and a baryon, while the pairing of dyons with antidyons of equal and opposite magnetic charge produces Bose-Einstein particles identified as mesons. It is also imagined, paralleling the electric-charge exchange mediated by weak interactions, that magnetic charge is rapidly exchanged among the dyon constituents of a magnetically neutral hadron in such a way that even the quite short time average of a particular dyon's magnetic charge will be zero. Conflict with the Fermi-Dirac statistics of dyons is avoided for the low-lying baryon states, which seem to be symmetrical in space and spin variables, by invoking the physical degree of freedom of magnetic charge and placing these quantum numbers in a totally antisymmetric state. The magnetic degree of freedom in this respect thus plays the same role as "color" in the orthodox quark-model description of hadrons.[10]

Specifically, the dyon structure which will explain the normal hadron spectroscopy is

$$\begin{aligned} &G_1={}^{2/3}D^{2/3} \quad G_2={}^{2/3}D^{-1/3} \quad G_3={}^{2/3}D^{-1/3} \\ &A_1={}^{-1/3}D^{2/3} \quad A_2={}^{-1/3}D^{-1/3} \quad A_3={}^{-1/3}D^{-1/3} \qquad (1)\\ &B_1={}^{-1/3}D^{2/3} \quad B_2={}^{-1/3}D^{-1/3} \quad B_3={}^{-1/3}D^{-1/3}, \end{aligned}$$

where the nine objects are all regarded as distinct particles, and the superscripts refer to the fractional magnetic (presuperscripts) and electric (postsuperscripts) charges. Basic questions such as the approximate but significant symmetries associated with isotopic spin and hypercharge are to be understood as dynamical manifestations of the spectra of the low-lying magnetically neutral states. For instance, the mechanism for magnetic-charge exchange[6] will tend to suppress those effects of order $eg_0/\hbar c$ (where g_0 is the smallest magnetic charge residing on a particle) that were called fine structure. The exchange mechanism itself produces mass splittings, however. Among the consequences of these couplings is a displacement in the masses of the individual dyons. There is a plausible expression for the exchange interaction that produces a mass splitting of a threefold electric multiplet into a doublet and a singlet, which gives an elementary account of the empirical properties of isotopic spin and hypercharge and may meet the challenge posed by the regularities observed in the properties of hadronic strong, electromagnetic, and weak interactions. However, it should be clearly understood that as the indirect influence of magnetic charge becomes more predominant at higher energies (presumably the physical dyons are quite massive), we *can* reasonably anticipate alterations to such relations as $Q=I_z+\frac{1}{2}Y$, even for magnetically neutral states.

In describing the meson spectrum in terms of dyon-antidyon states, we note first that we can form a magnetic-U(3) nonet from the three magnetic states G, A, and B and their antiparticles. This nonet can be decomposed into a singlet and octet of magnetic SU(3). It is natural to associate the singlet with the low-lying ordinary mesons. The octet, on the other hand, contains magnetically charged members, which we must assume to be very heavy. In fact, we assume that the splitting of the octet along the magnetic-charge direction is very large, so that the states are best characterized by magnetic charge, and the orthogonal SU(2), which is magnetic U spin. The magnetic-charge $\frac{2}{3}$ dyon, G, is taken to be a magnetic-U spin singlet in this picture, with the two magnetic-charge $-\frac{1}{3}$ dyons, A and B, regarded as members of a magnetic-U-spin doublet with $U_z=+\frac{1}{2}$ and $-\frac{1}{2}$, respectively. (In the remainder of this discussion, the term U spin will always refer to the magnetic degrees of freedom, and the qualifying adjective omitted.) The octet will have a pair of magnetically charged U-spin doublets, by our assumption very massive. The octet also includes magnetically neutral states which can be classified as a U-spin triplet and a U-spin singlet. The U-spin-singlet member of the octet is, of course, quite distinct from the low-lying meson states which are also classified in the U-spin singlet representation. We speculate that this second singlet may be associated with the Υ states observed by Lederman.[11] This leaves the U-spin triplet as a possible classification for the psions and those mesons identified in the orthodox model as "charmed." In Sec. III we will explore this possibility more thoroughly and consider an extension of the basic ideas to baryons.

III. DYON DESCRIPTION OF THE NEW PARTICLES

Within the meson U-spin triplet, each state of a given $U_z = 0, \pm 1$ is further split into nine different states distinguished by their electric quantum numbers. In contrast to the orthodox model, where the quarks are assumed to belong to an *exact* color SU(3), the magnetic SU(3) which classifies dyons is expected to be badly broken. The electric-SU(3) quantum numbers of dyon-antidyon states are not so obviously formed by assigning SU(3) quantum numbers to the constituents and adding them in the usual way. This is because the indices distinguishing the electric states of the different dyons G, A, and B will transform separately insofar as those dyons retain their identity. However, we know that, phenomenologically, the low-lying magnetic-singlet states can be account for by the addition of quantum numbers assigned to the constituents, and the usual nonet resulting from the direct product $3 \otimes \overline{3}$ describes the observed states quite well. Below we will attempt to infer from the phenomena what the appropriate classifications of the new particles should be in our scheme, and follow this with a rationale which suggests that these classifications are not unnatural.

A. The psions and the χ family

We assume that the $J/\psi(3.095)$, $\psi'(3.684)$, and $\psi''(3.772)(?)$ states belong to the $U_z = 0$ member of the U-spin triplet. Such states are linear combinations of $A\overline{A}$ and $B\overline{B}$, orthogonal to linear combinations of the same states which contribute to the U-spin-singlet ordinary mesons. We assume that they belong, as do the ordinary $J^{PC} = 1^{--}$ mesons, to a nonet of electric U(3). Possibly the χ states $\chi(3.415)$, $\chi(3.510)$, and $\chi(3.550)$ are $U_z = 0$ U-spin-triplet states with $J^{PC} = 0^{++}$, 1^{++}, and 2^{++}, respectively. However, since it is difficult to conceive of a mechanism which will place all of these different spin-parity multiplets (especially $J^{PC} = 2^{++}$) at masses between those of two members of our 1^{--} nonet, we prefer to identify the bulk of these states with the narrow resonances predicted by Brayshaw.[12] The $X(2.800)$, if it becomes firmly established as a $J^{PC} = 0^{-+}$ state, would be a candidate for a pseudoscalar member of the $U_z = 0$ U-spin triplet.

B. The $D(1.870)$ doublets and the $F^{\pm}$ singlets

The experimentally observed $I = \frac{1}{2}$ (D^+, D^0) and $(\overline{D}^0, D^-)$ doublets with $J^P = 0^-$, together with the $F^{\pm}(2.03)$ singlets,[13] pose the greatest challenge to any alternative description of the new particles. First, it is known[14] that $D^{\pm}$ decays predominantly into the $K^{\mp} + (\pi^{\pm}\pi^{\pm})$ exotic channels with a 90% experimental confidence limit on the ratio of nonexotic [e.g., $D^{\pm} \to K^{\pm} + (\pi^+\pi^-)$] to exotic decays of less than 5%. Second, parity violation is established in the decays of D to $K\pi\pi$ final states. As for the F, experiment suggests that it is pair produced with a heavier $F^*(2.14)$, which subsequently cascades to $F + \gamma$ in e^+e^- annihilation; the F decays into an $\eta\pi$ final state.

Qualitatively, the presence of parity violation in D decay into $K\pi\pi$ can be understood in the phenomenological picture.[4,5] This presumes that the "strong" decays of psions are indirect consequences of the electromagnetic interactions suppressed by nonconservation of U spin in our scheme, but U_z-conserving, and hence, naturally parity-conserving. However, in the decays of the D system (and perhaps the F), the strong interactions are further suppressed, so that we are seeing the genuine parity-violating weak interaction. In our scheme, this further suppression is naturally obtained by assigning the D and F to $U_z = \pm 1$ members of the U-spin triplet. Decays into normal hadrons must violate not only U-spin conservation, but U_z as well. To account for the fact that D decays are predominantly into exotic channels, we propose classifying the F^+, D^+, and D^0 in an (electric) SU(3) $\overline{3}$, as shown in Fig. 1(a). To as-

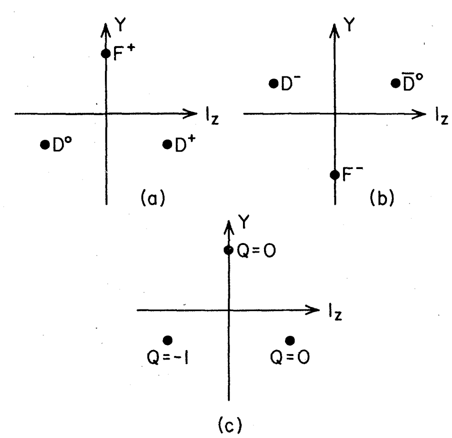

FIG. 1. Meson multiplets with $U_z = \pm 1$. (a) the $U_z = +1$ states with $\overline{Q} = +2/3$. (b) The $U_z = -1$ states with $\overline{Q} = -2/3$. (c) The $U_z = +1$ states with $\overline{Q} = -1/3$.

sign the correct integer charges, we assume that the Gell-Mann–Nishijima formula is modified to

$$Q-\overline{Q}=I_z+\tfrac{1}{2}Y, \tag{2}$$

where $\overline{Q}$ is the average charge of the multiplet (in this case, $+\frac{2}{3}$). Furthermore, we define the relation between strangeness and hypercharge to be

$$S=Y-\overline{Q} \tag{3}$$

for multiplets with nonzero $\overline{Q}$. For all the usual SU(3) multiplets employed in classifying normal hadrons, $\overline{Q}=0$, and Eqs. (2) and (3) reduce to the conventional relations. We assign $U_z=+1$ to this $\underline{\overline{3}}$; the antiparticles F^-, $\overline{D}^0$, and D^- then belong to a $\underline{3}$ with $U_z=-1$ as illustrated in Fig. 1(b). Pair production of $D\overline{D}$ and $F^\pm$ in e^+e^- annihilation (and indeed any other initial lepton or hadron configuration with $U_z=0$) is now required by conservation of U_z. This notion is extended in the obvious way to the $J^{PC}=1^{--}$ states such as $D^*(2.007)$ and $F^*(2.14)$. The definition of strangeness in Eq. (3) reflects an assumption that the dynamics obeys a

$$\Delta Y=\Delta\overline{Q} \tag{4}$$

rule,[15] and assigns $S=-1$ to the D system, and $S=+1$ to the $\overline{D}$ system. Thus the "exotic" decays are naturally predominant in our scheme, since they actually involve $\Delta S=0$. Similarly, $F^\pm$ decays into $(\eta\pi^\pm)$, an $I_z=\pm 1$ final state.

C. The $\Upsilon(9.5)$ state

Recent experimental work[11] on the dimuon spectrum in proton-nucleus collisions at 400 GeV suggests a dimuon peak enhancement in the general region of 9.5 GeV. The braod Υ enhancement region can be understood in terms of a structure composed of three separate peaks $\Upsilon(9.4)$, $\Upsilon'(10.0)$, and $\Upsilon''(10.4)$. In the present model, this would correspond to another set of relatively narrow 1^- states corresponding to the (ρ^0,ω,ϕ) and the $(J/\psi,\psi',\psi'')$. Qualitatively, we would not expect the Υ states to be as narrow as the psions, since we tentatively assign them to a U-spin singlet. However, their decays into ordinary hadrons are suppressed by violation of magnetic SU(3), since this U-spin singlet is part of the (magnetic) octet containing the U-spin triplet to which the psions are assigned. Decays into the psions are suppressed by U-spin conservation.

To provide a rationale for the assignments suggested above, we start from the phenomenological fact that the ordinary hadrons, which we take as magnetic-SU(3) singlets, can be classified in electric-SU(3) multiplets on the basis of the addition of SU(3) quantum numbers assigned to their constituents. We interpret this as due to the fact that the rapid exchange of magnetic charge provides a mechanism in which the dyons in these states essentially lose their identity, so that it is reasonable to regard the dyon-antidyon state as transforming as the product of a $\underline{3}$ and a $\underline{\overline{3}}$. We further assume that this property is retained, although with perhaps larger mass splittings within an SU(3) multiplet, for all states having the degree of magnetic symmetry implied by $U_z=0$. Thus we assign the psions and Υ states to electric-SU(3) octets and singlets. States with $U_z=+1$ (-1) are composed of $A\overline{B}$ $(B\overline{A})$, on the other hand. The dyons here must retain their identities in order that the state have a well defined U_z. We believe, therefore, that it is more appropriate to classify these states under $\mathrm{SU}(3)_A\otimes\mathrm{SU}(3)_B$, where each SU(3) refers to the group under which the electric indices of a particular dyon, A or B, transform. The $U_z=+1$ states are thus to be taken as belonging to the representation $(\underline{3},\underline{\overline{3}})$ of this group. To reproduce the assignments given above, we assume that the symmetry is broken first by a relatively large mass splitting along the dimensions of $\mathrm{SU}(3)_A$, leaving essentially three $\underline{\overline{3}}$'s with average charges $\overline{Q}=\frac{2}{3}$, $-\frac{1}{3}$, and $-\frac{1}{3}$. The first of these produces the classification previously assigned to F^+, D^+, and D^0. We expect an additional pair of $\overline{3}$'s, each of the type given in Fig. 1(c). In these multiplets, the isosinglet member will have $S=+1$, and the isodoublet will have $S=0$, applying the rule given by Eq. (3).

The above rationale allows us to extend our speculations to the baryons. The normal baryons are assigned to the U-spin singlet, and we expect their electric quantum numbers and those of the $U_z=0$ member of the U-spin triplet to be classified in the usual multiplets. We can look for unusual properties in the $U_z=\pm 1$ members of the U-spin triplet. The $U_z=-1$ states will be GBB composites, for example. Under $\mathrm{SU}(3)_G\otimes\mathrm{SU}(3)_B$ these will belong to the $(\underline{3},\underline{3}\otimes\underline{3}=\underline{6}\oplus\underline{\overline{3}})$. Guided by our rationale for mesons, we predict that these 27 states will be grouped into a $\underline{6}$ and a $\underline{\overline{3}}$ with $\overline{Q}=\frac{2}{3}$, and pairs of $\underline{6}$'s and $\underline{\overline{3}}$'s with $\overline{Q}=-\frac{1}{3}$. These representations, with charges assigned using Eq. (2), are illustrated in Fig. 2. For baryons, we must modify Eq. (3) to read

$$S+B=Y-\overline{Q}, \tag{5}$$

in order to recover the usual relation when $\overline{Q}=0$. Applying Eq. (5) to the $\underline{6}$ with $\overline{Q}=\frac{2}{3}$, we find that the isotriplet with charges (++ ,+ ,0) has $S=-1$, the isodoublet with charges (+ ,0) has $S=-2$, and the neutral isosinglet has $S=-3$. The doubly charged particle in this representation is an ob-

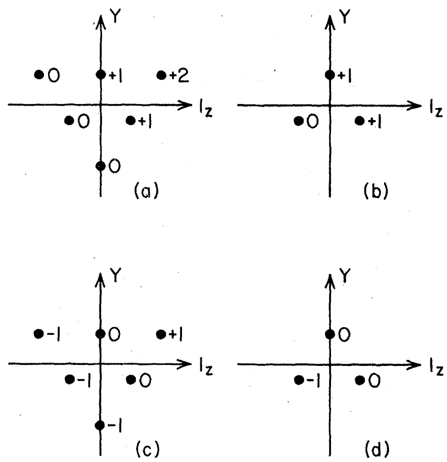

FIG. 2. Baryon multiplets with $U_z=-1$. (a) The $\underline{6}$ representation with $\overline{Q}=\frac{2}{3}$. (b) the $\overline{\underline{3}}$ representation with $\overline{Q}=\frac{2}{3}$. (c) The $\underline{6}$ representation with $\overline{Q}=-\frac{1}{3}$. (d) The $\underline{\overline{3}}$ representation with $\overline{Q}=-\frac{1}{3}$.

vious candidate for the $(\Lambda^0\pi^+\pi^+\pi^+\pi^-)$ state observed recently[16] at 2426 MeV. Using Eq. (5) for the $\overline{3}$ with $\overline{Q}=\frac{2}{3}$, gives $S=-1$ for the positively charged isosinglet, and $S=-2$ for the isodoublet with charges (+, 0). The antiparticle of the isosinglet in this representation may be identified with the observed[17] antibaryon state $(\overline{\Lambda}\pi^-\pi^-\pi^+)$ at 2260 MeV. Relatively strong decay of the 2426-MeV state into the positively charged isosinglet at 2260 MeV (accompanied by a π^+) is expected in our scheme (as well as in the orthodox model which takes these states to be charmed baryons) since U spin and U_z are conserved.

IV. EXPERIMENTAL CONSEQUENCES

The notions we outline here would receive enormous encouragement if an $I=1$ ψ'' is found in the vicinity of $\psi'(3.684)$. The experimentally found $\psi''(3.772)$ could be such a state. This state decays dominantly[14] (99%) into $D\overline{D}$ despite very limited phase space and is an allowed decay in our framework since the $(D\overline{D})$ configuration has $U_z=0$. However, the Clebsch-Gordan coefficients for the experimentally accessible $\psi''\to D^+D^-$ and $D^0\overline{D}^0$ decays do not yield information on the I spin of ψ''. The decay $\psi''(3.772)\to J/\psi+\pi^0$ is allowed in our scheme; however, it must be stressed that the yield of J/ψ is surprisingly small not only at $\psi''(3.772)$ but also[14] at the e^+e^- annihilation peaks $\psi(4.028)$ and $\psi(4.4)$—a problem we share in large measure with the orthodox charm picture. The leptonic width $\Gamma_e=0.37$ keV for $\psi''(3.772)$ does not accord with the famous $9:1:2$ ratio approximately valid for (ρ^0, ω, ϕ) when taken in conjunction with the leptonic widths of $\psi'(3.684)$ and $J/\psi(3.095)$; this need not be surprising in view of our limited understanding of the dynamical influence of the virtual magnetic effects due to dyons. The charged members of an $I=1$ ψ'' cannot be easily identified in e^+e^- annihilation, though they may in principle[18] be looked for in $pp\to(\psi'')^{\pm}+X$, $\psi''\to D^+\overline{D}^0$, D^-D^0 [or $\psi''\to J/\psi$ $(\to\mu^+\mu^-)+\pi^{\pm}$] by a study of the appropriate mass plots. Since our understanding here is a radical departure from the charmonium picture,[19] where the $\psi''(3.772)$ is believed to be[8] an $I=1$, $^3D_1$ state, we urge increased effort towards resolving the isospin of this state. We cannot, of course, rule out the (less attractive) possibility that the $I=1$ ψ'' lies below the $D\overline{D}$ threshold but in the vicinity of $\psi'(3.684)$. This may become easier to uncover in e^+e^- annihilation, as well as pp production, should the $\psi''\to J/\psi+\pi$ decay be as naively expected. The 3.772 state would then be regarded as a molecular resonant state[20] of $D\overline{D}$ in either $I=0$ or $I=1$. The assignment of the psions to $U_z=0$ allows for the possibility of $(I,J^P)=(\frac{1}{2},1^-)$, $S=\pm1$ partners to complete the electric nonet; these are, however, unlikely to be seen at SLAC-SPEAR energies since they need to be pair produced in e^+e^- annihilation. The X (2.8) with $U_z=0$ is also likely to belong to an electric nonet, hence the spectrum in the vicinity of 3 GeV should include two $I=0$ and one $I=1$ pseudoscalar states.

We would expect the Υ peaks to contain two $I=0$ and one $I=1$ $J^{PC}=1^{--}$ states. This is in contrast to orthodox theory,[21] where the peaks in the 9.5-GeV region are interpreted as $I=0$ states formed from bound states of a new b quark. It would be of interest, therefore, to search for the charged partners of the $I=1$ member in proton-nucleus collisions[11] at 400 GeV.

Concerning the baryons, the following remarks are appropriate. Nothing in the magnetic model[6] precludes the existence of a class of a new baryons which decays slowly into the known hadrons of relatively low mass. For instance, baryon states which are symmetric in magnetic charge but antisymmetric in electrical charges again give the correct spin-statistics relationship, but are, of course, "orthogonal" to the low-lying baryon states which are symmetric in electric but antisymmetric in magnetic charges. Transitions between them are necessarily slow though parity conserving as befit "suppressed" strong interactions with an ultimate electromagnetic origin. Analogous to the psions, we classify these states as the $U_z=0$ member of a magnetic-U-spin triplet, while consigning the usual baryons (Δ, N, Λ, etc.) to $U_z=U=0$. These new baryons (which have no analogs in the orthodox charm theory) have conventional isotopic-spin and strangeness assignments but have attentuated strong decays (and hence *narrow* widths) into the usual baryons and mesons, e.g., $\Delta'^{++} \to p + (\Delta S = 0 \text{ mesons})^+$, etc. If these new baryons should lie in the same mass range as the $(\Lambda^0\pi^+\pi^+\pi^-)$ state[16] observed at 2426 MeV, or the antibaryon state[17] $(\bar{\Lambda}^0\pi^-\pi^-\pi^+)$ at 2260 MeV, the opening of these new channels could possibly account for the rise in the ratio of $p\bar{p}/\Lambda\bar{\Lambda}$ production in e^+e^- annihilation reported recently.[22]

The baryons with $U_z = -1$, $U = 1$ are also substantially richer than their charm analogues.[23] The (GBB) combination with $\bar{Q} = \frac{2}{3}$ includes not only the set given by Fig. 2(a) and Fig. 2(b) which appears (but, of course, with the different strangeness assignments) in the charm scheme, but two additional sets with $\bar{Q} = -\frac{2}{3}$ [Fig. 2(c) and Fig. 2(d)] which do not appear in the orthodox theory. Another set with the same quantum numbers is required for the combination (GAA) with $U_z = +1$.

Last but not least, it must be clearly emphasized that the magnetic model will have no real meaning, *unless ultimately massive magnetically charged hadrons are found.*

V. CONCLUSION

The reader will readily agree that the proposal sketched out above is at best a skeleton of a theory. In contrast with the advances made in the orthodox quark model with four, and now perhaps five, flavors and three colors, we have made no attempt to deal systematically with the interesting question of the weak interactions or with a specification of the dynamics of dyon interactions. That the landscape of this theory should appear so barren compared to that of the fashionable theory is not surprising, however, given that a large fraction of the world's theoretical physics resources in recent years has been devoted to the latter, while the former has been largely neglected even by its author. What we hope to have demonstrated, by this modest attempt to remedy that neglect, is that the dyon model may be a viable alternative to the conventional approach.

Having thus admitted to the obvious deficiencies of the present state of the theory, we would like to point out a major virtue. The results we have presented are achieved without the need for new constituents; i.e., the same dyons required to explain the ordinary (precharm) hadrons appear capable of combining to form states with characteristics like those of the newly discovered particles. The same basic degree of freedom, magnetic charge, that was introduced to solve the statistics problem for baryons, has been extended here to provide a framework for particles which in the orthodox theory requires the proliferation of quark flavors from three to five.

Note added in proof. (1) It has been pointed out to us by J. D. Bjorken that another way of checking an $I = 1$ assignment for the $\psi''(3.772)$ would be via the decay

$$\psi(4.1) \to \psi''^-(3.772) + \pi^+, \quad \psi''^- \to D^0\bar{D}^-$$

i.e., mass recoiling against π^+ to look for peak in the momentum spectrum of the pion (two-body decay). The problem here is that we do not know the branching ratio for this decay (which might well be small), since the analogous yields at 4.1 for $J/\psi, \psi'$ members of the family are known to be *small*. However, if the $\psi''(3.772)$ is not a Schwinger state, but a molecular charmonium state with $I = 1$ say, then $\psi(4.1) \to \psi''^-(3.772) + \pi^+$ is expected to be *large* and indeed might well be faily accurately estimated using phase-space arguments for the $D\bar{D}\pi$ final-state interaction.

(2) The Υ peaks as a magnetic-U-spin singlet can be expected to decay *faster* than the psions ($\Gamma \gtrsim 100$ keV). This is to be contrasted with the orthodox b or t quark picture [K. Gottfried, in *Proceedings of the International Symposium on Lepton and Photon Interactions at High Energies, Hamburg, 1977,* edited by F. Gutbrod (DESY, Hamburg, 1977), p. 667], where typically for $\Upsilon(9.4)$ say, $\Gamma \lesssim 35$ keV.

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