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Further Evidence for Magnetic Charge from Meson Spectroscopy

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Recently evidence was presented for the existence of magnetic charge from Zeeman splitting in meson states. The model by Akers predicted the existence of a new η meson at 1814 MeV with $I^G(J^{PC}) = 0^+(0^{-+})$. Experimental evidence for this new meson is cited and discussed.

1. INTRODUCTION

In this paper I discuss the recent experimental evidence for magnetic charge from meson spectroscopy. There is evidence (Akers, 1985) that a magnetic monopole of Dirac charge $g = (137/2)e$ may be Zeeman-splitting meson states. Akers (1986) presented an analysis of the Zeeman splitting and suggested it was due to the interaction between a magnetic monopole and a c-quark's magnetic dipole moment. Later, Akers (1987) suggested that the interaction involved a pair of dyons with electric and magnetic charges (Ze, g) and $(-Ze, -g)$, where Z may be integral or fractional (Schwinger, 1969).

From the analysis of the Zeeman splitting, Akers (1986, 1987) predicted the existence of a new η meson at 1,814 MeV with $I^G(J^{PC}) = 0^+(0^{-+})$. The existence of this new meson would be evidence for the presence of magnetic charge involved in Zeeman splitting of isospin $I = 0$ mesons as shown in Figure 1. There is now evidence (Baltrusaitis *et al.*, 1985, 1986) for a new η resonance at 1.8 GeV found in two different experiments. A study of the recent evidence is presented in Section 2. In Section 3, I present concluding remarks.

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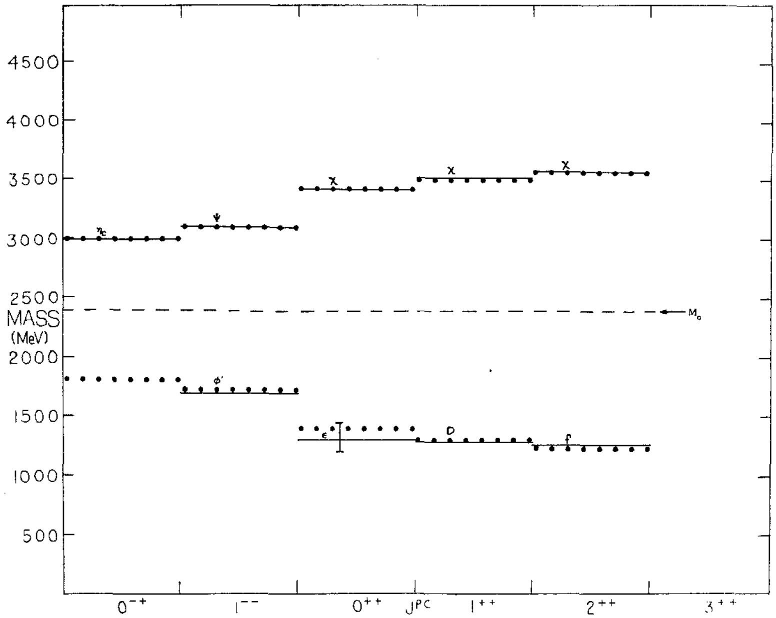

Fig. 1. Zeeman splitting of isospin $I=0$ mesons, from Akers (1987). The dashed line represents the mass $M_0 = 2397$ MeV of the magnetic monopole. The dotted lines are theoretical values for meson masses based upon the model by Akers. The experimental masses are indicated by solid lines. An error bar is shown for $\varepsilon(1{,}300)$. A missing η meson is indicated in the $J^{PC}=0^{-+}$ bin.

2. MESON SPECTROSCOPY

Particle physicists are searching for evidence of a $J^{PC}=0^{++}$ or 0^{-+} glueball in the 1- to 2-GeV mass region (Seiden, 1986; Meshkov *et al.*, 1987). In recent experiments in J/ψ decays, researchers have discovered several structures in the 1.4- to 1.9-GeV mass region. The Mark-III Collaboration has found peaks at 1.55 and 1.8 GeV in $J/\psi \to \gamma\rho\rho$ (Baltrusaitis *et al.*, 1986) and again at 1.8 GeV in $J/\psi \to \gamma\omega\omega$ (Baltrusaitis *et al.*, 1985). These structures were seen in earlier experiments (Wermes, 1984), as shown in Figure 2. Achasov and Shestakov (1985) studied the results of $J/\psi \to \gamma\rho\rho$ and suggested that the peak near 1.8 GeV in Figure 2 was due to the tail of the η' at 1.44 GeV interfering with $\iota(1{,}440)$. Their calculation for the $\rho\rho$ mass distribution is shown as a solid curve in Figure 2. Notice that there is a peak at 1.8 GeV, which rises above the distribution calculated by Achasov and Shestakov. The spin-parity of this structure was determined to be $J^P=0^-$ (Richman, 1984; Wermes, 1984).

Another recent experiment (Berger *et al.*, 1985) found evidence for a new resonance at 1.8 GeV, as shown in Figure 3. However, the Pluto

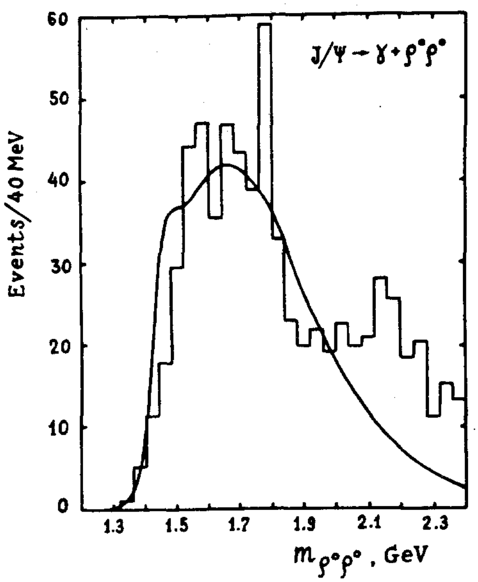

Fig. 2. The $\rho\rho$ mass spectrum in $J/\psi \to \gamma\rho\rho$ decay, from Wermes (1984). The solid curve represents the mass distribution calculated by Achasov and Shestakov (1985). Note the peak at 1.8 GeV, which rises above their curve.

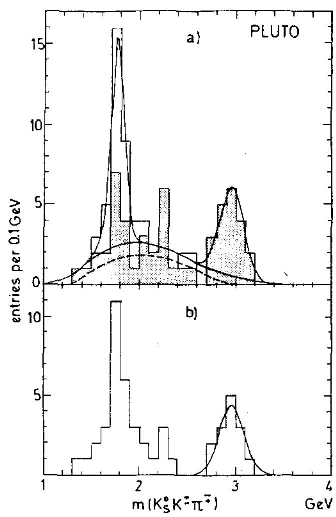

Fig. 3. Invariant $K^0_S K^\pm \pi^\mp$ mass distribution, from Berger *et al.* (1985) (a) A full data sample. Note there are peaks at 1.8 and 3.0 GeV, both fitted by Gaussians. The shaded histogram is an analysis by Berger *et al.*, excluding events that are not compatible with the final state $K^0_S K^0_S$. (b) A restricted data sample, where background events have been subtracted.

Collaboration noted the two peaks at 1.8 and 3 GeV, and they explained that the peak at 1.8 GeV was due to events of the type $\gamma\gamma \to f' \to K_s^0 K_s^0$, which shifted the 1.5-GeV mass of f' upward to 1.8 GeV. The shaded histogram in Fig. 3 corresponds to events that are not compatible with the final state $K_s^0 K_s^0$. Note that a peak remains at 1.8 GeV and a new one appears at 2.2 GeV from the analysis (shaded area) of Berger *et al.* (1985). However, I will not be the first to claim evidence of $\eta(1{,}814)$ from these data, even though a similar experiment has found a 1.8-GeV peak in $J/\psi \to \phi K^{\pm} K_s \pi^{\pm}$ (Köpke, 1986). Seiden (1986) suggested that the structures seen in these experiments near 1.6 and 1.9 GeV may match those seen in the $\gamma\rho\rho$ and $\gamma\omega\omega$ final states at 1.55 and 1.8 GeV (Baltrusaitis *et al.*, 1985, 1986).

Perhaps the most convincing evidence of $\eta(1{,}814)$ is found in observations of $J/\psi \to \gamma\rho\rho$ and $J/\psi \to \gamma\omega\omega$ by Baltrusaitis *et al.* (1985, 1986). They studied $\omega\omega$ mass distributions between 1.6 and 2.8 GeV/c^2 and found a peak at 1.8 GeV/c^2. Baltrusaitis *et al.* (1985) concluded from a partial-wave analysis that the $\omega\omega$ signal near 1.8 GeV/c^2 is predominantly $J^P = 0^-$ in spin and parity.

Furthermore, Baltrusaitis *et al.* (1986) found peaks at 1.55 and 1.8 GeV/c^2 in the 4π invariant-mass distributions of $J/\psi \to \gamma\rho\rho$ extended from 1.0 to 3.0 GeV/c^2. They completed a partial-wave analysis of the mass distributions, concluding a $J^P = 0^-$ for the $\rho\rho$ component or η resonance near 1.8 GeV/c^2.

3. CONCLUSION

I summarize the evidence for $\eta(1{,}814)$ in Table I. The experiments of J/ψ decay by Baltrusaitis *et al.* (1985, 1986) are the most convincing evidence for a new η resonance at 1.8 GeV. Others have suggested that the peaks at 1.55 and 1.8 GeV are the radial excitations of the η and η' (Barnes and Close, 1985). However, in their analysis of the i/E system, Meshkov *et al.*

Table I

Experiment	Meson mass (GeV)	$I^G(J^{PC})$	Reference
Zeeman splitting	1.814	$0^+(0^{-+})$	Akers (1985, 1986)
$J/\psi \to \gamma\rho\rho$	1.8	0^-	Baltrusaitis *et al.* (1985)
$J/\psi \to \gamma\omega\omega$	1.8	0^-	Baltrusaitis *et al.* (1986)
$J/\psi \to \phi K^{\pm} K_s \pi^{\pm}$	1.8	?	Köpke (1986)
$e^+e^- \to e^+e^- K_s^0 K^{\pm} \pi^{\mp}$	1.8	?	Berger *et al.* (1985)
$J/\psi \to \gamma\rho\rho$	1.8	0^-	Wermes (1984)

(1987) identified the 1.8-GeV peak as a new resonance or η meson. It remains to be seen from future experiments whether the $J^P = 0^-$ peak at 1.8 GeV is the predicted meson by Akers (1986).

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