and the ρ-exchange contribution to the $K^*(890)$ amplitude are both small, and if the $I = \frac{1}{2}$ s wave resonates with nearly the same mass and width as those of the $K^*(890)$; see Yuta *et al.*, Ref. 2.

[18] It is because of the tight constraints imposed by the positivity conditions (6) that we are unable to obtain good fits to the data with $\tau \gtrsim 15\%$ and $\Gamma_s \lesssim 80$ MeV. With the φ dependence removed for the fit, the conditions (6b) and (6c) reduce to just one constraint, i.e., $e \geq |v|^2$, allowing for a wider latitude in the fit for the values of τ and Γ_s.

[19] We obtain $\tau = 0.27$ for the "up" solution of Yuta *et al.*, using the numbers quoted in the paper. We find that the value of τ can vary from 0.35 to 0.20 as $2\alpha_\rho$ goes from 0 to 1 ($2\alpha_\rho$ is the fraction of the vector-exchange contribution), while it is relatively insensitive to the $I = \frac{3}{2}$ s-wave contribution.

[20] It should be noted that the density-matrix formalism and the corresponding positivity constraints are rigorously true regardless of the production process; in particular, this is true even in the presence of a reflection from, say, the N^* production. Therefore, further assumptions are necessary if one wants to extract the π-exchange component from the results of our fit.

Singlet Boson Trajectory

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A quark-model state ${}^1F_3$ is assigned in the presumably Q-like $K\pi\pi$ peak around 2.16 GeV. The resulting Regge trajectory in linear and exchange degenerate and has an anomalous slope, $\alpha' \simeq 0.67$ GeV^{-2}. The fundamental significance of this nonparallelism is pointed out, and measurements are proposed to confirm the assignment.

This note is to point out an experimental candidate for the fourth quark-model state on the singlet boson trajectory (${}^1F_3$), and to suggest means of confirming that assignment. This would permit the first establishment of slope linearity and exchange degeneracy as independent facts for the singlet tragectory; they are important for the reasons detailed in the next two paragraphs.

The argument that Regge trajectories comprise resonances formed by pairs of other particles themselves also lying on Regge trajectories leads to the conclusions that asymptotically all infinitely rising trajectories must be parallel,[1] and that all straight-line trajectories connectible by pion emission must be parallel.[2] Empirically,[3] all baryon trajectories and the leading boson trajectory have slopes enough like $\alpha_0' = 0.9$ GeV^{-2} to support the idea of a universal slope within present uncertainties. The question of parallelism among the four principal boson trajectores of the quark model was discussed in this light with earlier data,[4] and the chief requirement inferred was that the π and B mesons lie on separate trajectories. Exchange degeneracy of the π and B would imply $\alpha' < 0.7$ GeV^{-2} for the ${}^1L_L$ trajectory, at least to begin with; $\alpha' \to 0.9$ GeV^{-2} could be approached asymptotically only if the trajectory were curved.

Recent surveys of quark-model assignments[5,6] show that evidence for the universal slope is as good as previously, *except* that identification of A_3 as ${}^1D_2$ suggests the singlet trajectory to be disturbingly straight, exchange degenerate, and nonuniversal in slope with $\alpha' \lesssim 0.7$ GeV^{-2}. This is not within experimental uncertainty of α_0'. The assignments of Ref. 6 really allow the ${}^3L_{L-1}$ trajectory to be parallel to the leading ${}^3L_{L+1}$, especially if the δ mass is taken[5] as 962 MeV. The ${}^3L_L$ trajectory is not very complete experimentally, although identification of the ${}^3D_2$ as the F_1 (1540) may supply one of the missing states required in Ref. 4.

The ${}^1F_3$ candidate is the relatively prominent and isolated $K^* \to K\pi\pi$ resonance observed[7] at 2.16 ± 0.04 GeV. The position of the associated $I = 1$ state is supposed to follow from the general rule[8,9] that $m^2(K) - m^2(\pi) \approx m^2(K^*) - m^2(\rho) \simeq \ldots \simeq 0.25 \pm 0.05$ GeV^2, or hence $m({}^1F_3, I = 1) = 2.10 \pm 0.05$ GeV. The η-type state of ${}^1F_3$ should be in the neighborhood of the K^*, though perhaps weakly perturbed by the η'. The weakness of this perturbation is discussed below. Evidence for a $K_SK_S\omega$ resonance at 2176 MeV, which has the correct $C = -1$, was presented[10] at the Lund Conference; in a more complete report[11] this evidence had weakened, but the suggestion of a peak in the cross sections $\bar{p}p \to K_SK_S\omega$ remained around 2.15 GeV.

The η'-type particle that completes the $^1F_3$ nonet cannot be specified at this stage. For quark-model singlets the only known η' is the $\chi^0(^1S_0)$, which is widely displaced from the η and probably has a small mixing angle like 10°. This is in accord with theoretical expectations[8] of significant mass dependence on SU(6) representations, which separates the spin-singlet, SU(3)-singlet state from the remaining 35 spin-SU(3) states of a fixed L.

Empirically, this feature can be used in reverse: Just for the singlet states the SU(3) octet alone should form a consistent trajectory with little perturbation from the η' trajectory. That such perturbation can be satisfactorily neglected for S and P orbitals has appeared in previous surveys.[12] Accordingly, we plot in Fig. 1 the mean octet value $M^2 = \frac{1}{8}(m_\pi^2 + 3m_\eta + 4m_K^2)$. Within uncertainties the plot is linear and exchange degenerate, and has a slope distinctly less than the otherwise "universal" value. This violates any nonasymptotic theorems of parallelism.

Determination of the J^P value for the $K\pi\pi$ peak at 2.16 GeV is an obvious step. The situation is probably analogous to the Q region, which probably harbors both the $^1P_1$ and $^3P_1$ quark-model states with a somewhat indeterminate amount of mixing. For this reason it may not be possible to specify the $K^*(^1F_3)$ mass very exactly.

Clearly, the strongest confirmation would be in the associated $I = 1$ state at about 2.10 GeV —call it B_3. By analogy with $A_3 \to \pi f$ and $B_1(1233) \to \pi\omega$, we expect that the dominant if not practically exclusive mode of B_3 decay will be $B_3 \to \pi\omega'$ with a width $\Gamma \gtrsim 100$ MeV.[13] Here ω' is the ω type for $^3D_3$, which has been associated[14] with the $I^C = 0^-$ state at 1680 MeV.

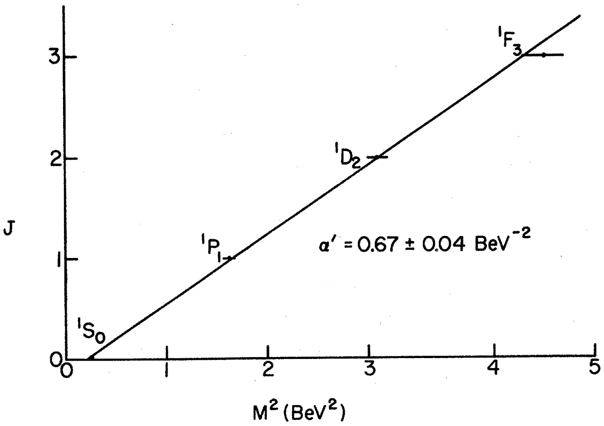

FIG. 1. Straight-line trajectory for SU(3)-octet ^1L_L states.

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