Radial Trajectory for A1 Mesons

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Boson radial trajectories were launched by the seminal work of Veneziano [1], which provided a Regge scattering amplitude both unitary and symmetric in the Mandelstam variables s, t, u. The price for this feat was limitation to perfectly linear trajectories: $\alpha(m^2) \equiv \alpha(0) + m^2\alpha'$. where m^2 is the invariant $(mass)^2$ associated with a pole in the s, t, or u channel of boson-boson scattering and α' is a universal slope. The linear spacing Δm^2 between successive poles in any channel was given by $2 = \Delta\alpha = (\Delta m^2)\alpha'$. In the following we define a "slope" inverse to α': namely, $A = \Delta m^2/\Delta N = 2/\alpha'$ where N is the "radial" quantum number of a light meson sequence with constant external parameters L, J, P, C, I. In the 30-plus years since publication of Ref. [1] enough data on light mesons have accumulated to enable an empirical survey of A for some cases. Although currently limited in number, these instances do in fact suggest a universal slope expressed by

$$A = 1.04 \pm .02 \text{ GeV}^2 \tag{1}$$

We display preliminary estimates of A (Fig. 1) and make application of A to the $\tilde{f}_2(s\bar{s})$ sequence (Fig. 2) and to a_1. The original paper [1] entailed equally restrictive choices for the intercepts $\alpha(0)$; but current statistics on this quantity are too limited for study. Figure 1 exhibits the best trajectories to date: f_2 and a_2. Similar plots for ρ and f_0 yield parallel lines of less precision; Eq. (1) is the error-weighted average of all four cases and is compatible with each of them. Extended surveys are planned [2].

The attempt to find the a_1 radial sequence yields an unanticipated result. Here the best determined masses [3] are for N = 2 and N = 3, and their m^2 difference is compatible with Eq. (1). Extrapolating from these values to N = 1 indicates

$$m^2(a_1/N = 1) = 1.81 \pm .05 \text{ GeV}^2 \tag{2}$$

about a 3σ difference from the conventional $m^2(a_1/N = 1) = 1.51 \pm .10$ GeV^2, derived mainly from τ decays [4]. If the assignment in Eq. (2) is correct, it tends to validate Wolfram's theorem [5] forbidding $\tau \to a_1(q\bar{q}) + \nu$ to lowest order for any N. As a guide to this discrepancy, we list a number of relevant experiments [5].

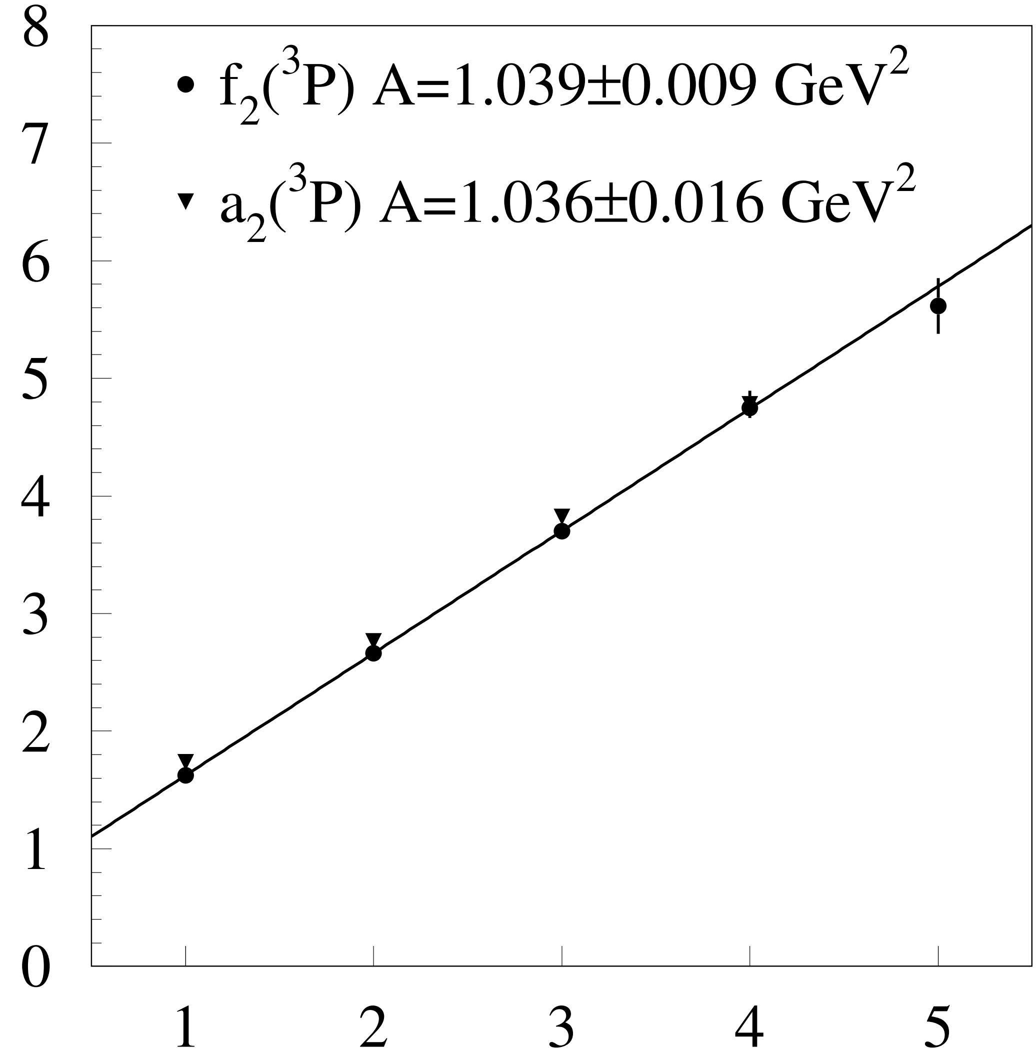

Figure 1: $m^2(GeV^2)$ v/s N

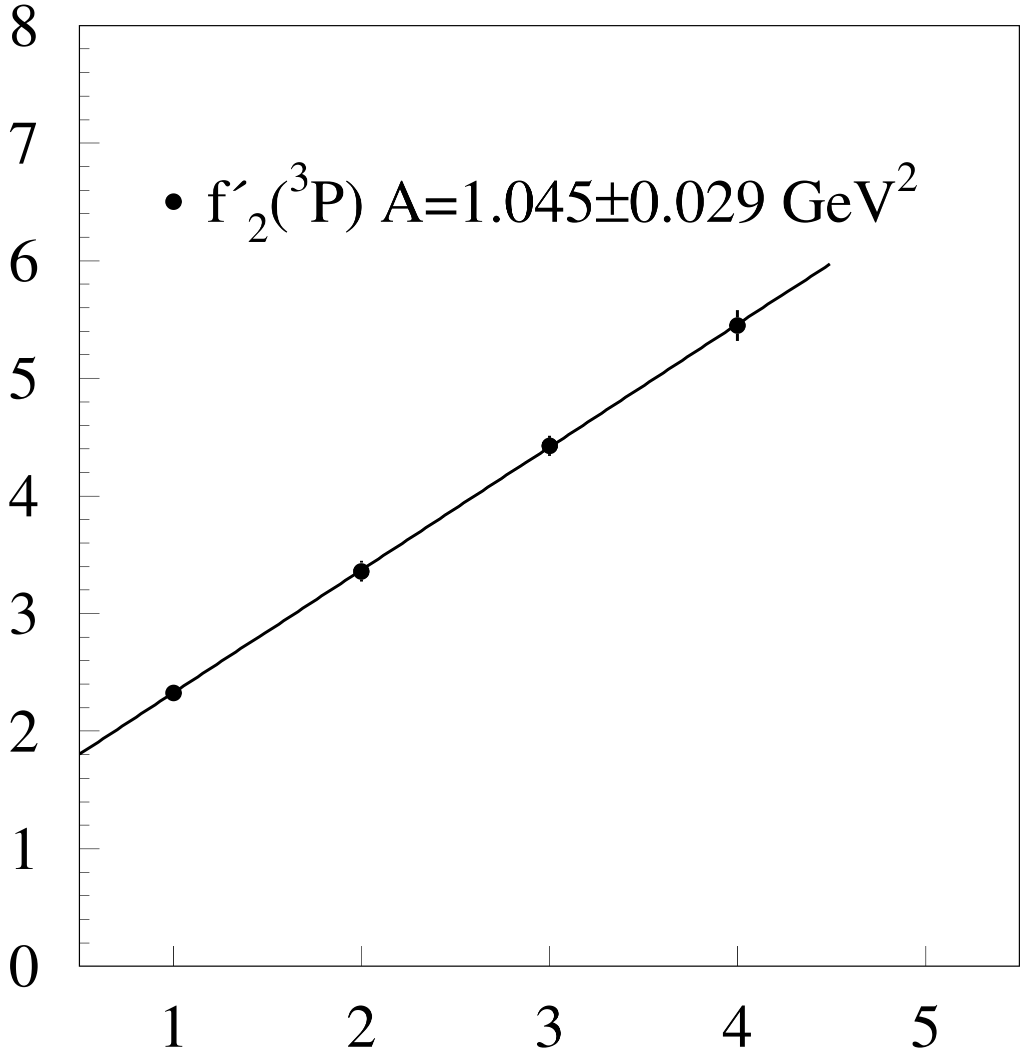

Figure 2: $m^2(GeV^2)$ v/s N

Application of Eq.(1) to the $s\bar{s}$ combination $\tilde{f}_2$ is straightforward. The reaction $\pi^- p \rightarrow \phi\phi n$ has yielded three 2^+ resonances [6,7], one with mass $m(N) = 2.334 \pm .028$ GeV. Upon taking [3] the ground state mass to be $m(1) = 1.525 \pm .005$ GeV, we obtain

$$m^2(N) - m^2(1) = 3.122 \pm 0.132 \text{ GeV}^2 \tag{3}$$

This is in perfect agreement with Eq. (1) if N = 4; the corresponding masses in GeV for the intermediate states would then be $m(2) = 1.835 \pm .013$ GeV, m(3) = $2.100 \pm .021$ GeV. In fact m(3) has already been seen – with spin [8] $J^{PC} = 2^{++}$ and mass [9] 2104 ± 20 MeV. A confirming feature is the absence of pure $\pi^0\pi^0$ decay for this state, revealed only in $\eta\pi^0\pi^0$ [8] and $\eta\eta$ [9] modes, which suggests an $s\bar{s}$ structure. Finally, at this conference a candidate for $\tilde{f}_2(2)$ is reported [10] at 1833 ± 24 MeV; although its J^P is yet unmeasured, its decay chain has an $s\bar{s}$ signature: $J/\psi \rightarrow \gamma \tilde{f}_2(2)$, $\tilde{f}_2(2) \rightarrow \gamma\phi$.

An important corollary of the universal trajectory concept: Given a certain mass pattern among different LJPCI levels at the N = 1 level, the whole pattern translates to all higher N values, modulo the $\pm 2\%$ uncertainty in Eq. (1). Study of the $\tilde{f}_2$ trajectory provides a chance to test such a "translation effect". At N = 1 the mass difference δm between $\tilde{f}_2$ and $\tilde{f}_1$ is supposed [4] to be limited by $|\delta m| \leq 15$ MeV. This is comparable to the fluctuations in Eq. (1), so each $\tilde{f}_2(N)$ should have a sensibly degenerate partner $\tilde{f}_1(N)$. For $\tilde{f}_1$ the major decay mode must be $K\bar{K}\pi$ which is also accessible to $\tilde{f}_2$. Careful analysis of such 3-body decays should reveal some $2^+ - 1^+$ interference, with $\tilde{f}_1, \tilde{f}_2$ resolvable by independent knowledge of $\tilde{f}_2$ from 2-body decays.

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