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THE PION CONSPIRATOR: A FURTHER EVIDENCE FOR ITS EXISTENCE AND A DISCUSSION ON ITS IMPLICATIONS IN MESON SPECTROSCOPY

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In previous papers [1,2] strong evidence for the existence of a class III pion conspiracy in π^+ photoproduction has been provided. This has been achieved by studying with the continuous moment sum rules [3] the amplitudes $F_2^{(-)}$ and $F_3^{(-)}$ ‡. In this note new evidence is presented for a Regge pole pion conspirator π_c. In fact, analysing by the same technique the amplitude $F_1^{(-)}$ (to which A_2 and π_c can contribute) we have found, besides the A_2, a Regge pole with the same trajectory previously determined for π_c from the conspiring amplitude $F_3^{(-)}$. This result confirms the existence of the pion conspirator Regge pole.

We also find the Regge parameters of the A_2, which provide the dominant contribution at small t; it results that the A_2 chooses the Chew or the non-compensating mechanism when $\alpha_{A_2} = 0$ ($t \approx -0.60$) ‡‡.

Moreover, we discuss the connection between the existence of the π_c and the doublet structure of the A_2 resonance [6], and give some arguments to classify the A_1 resonance as a recurrence of the first pion daughter. The possibility of considering the A_3 [7] as a further recurrence of this trajectory is also discussed.

The sum rule used has the form:

$$\phi(\gamma) = (\nu_{\max})^{-\gamma} \left\{ \frac{\mu}{\pi} \int_{\nu_0}^{\nu_{\max}} [\nu^2 - \nu_0^2]^{\frac{1}{2}\gamma} \mathrm{Im}[\exp(-\tfrac{1}{2}\mathrm{i}\pi_\gamma) F_1^{(-)}(\nu,t)]\,\mathrm{d}\nu - \tfrac{1}{2} ef\,[1+\mu_p - \mu_n][\nu_0^2 - \nu_B^2]^{\frac{1}{2}\gamma} \right\} =$$

$$= \frac{\mu s_0}{2\pi M} \sum_k \frac{\alpha_k(t)\beta_k(t)}{\sin[\frac{1}{2}\pi\alpha_k(t)]} \frac{\sin[\frac{1}{2}\pi(\alpha_k(t)+\gamma)]}{\alpha_k(t)+\gamma} \left(\frac{2M\nu_{\max}}{s_0}\right)^{\alpha_k(t)} \qquad (1)$$

where, at high energy

$$F_1^{(-)} \approx \sum_k \alpha_k(t)\beta_k(t) \frac{1+\exp(-\mathrm{i}\pi\alpha_k)}{\sin\pi\alpha_k} (2M\nu/s_0)^{\alpha_k - 1} \qquad \text{and} \qquad s_0 = 1\ \mathrm{GeV}^2 . \qquad (2)$$

As previously, the low-energy fit done by Walker [8] has been used for the evaluation of the integral. The range of t considered is $-0.7 \leq t \leq 0.3$.

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‡ We use the same notations as ref. 1 and 2. See also ref. 4.

‡‡ This is in agreement with the indications obtained using integer moment sum rules [5].

For $t \gtrsim -0.1$ we find a clear dominance of the A_2 pole (see, for instance, in fig. 1a, $\phi(\gamma)$ at $t = 0.10$). However, the curves are not pure one-pole and the introduction of a second pole does not explain the deviations from the pure one-pole behaviour; we are oriented to believe that these deviations are essentially due to errors. We have then fitted the curves in this region of t with the A_2 pole only. We have found $\alpha_{A_2}(0) = 0.6$ and $\alpha'_{A_2}(0) = 0.95$. However the errors are large. From the irregularities of the $\phi(\gamma)$'s we may estimate an error ≈ 0.2 on $\alpha_{A_2}(0)$, while $\alpha'_{A_2}(0)$ may really range between 0.35 and 1. Therefore one has a rough compatibility with previous fits to η production [9] ‡.

For $t \lesssim -0.45$ another contribution becomes dominant. From fig. 1b, which represents $\phi(\gamma)$ at $t = -0.45$ and $t = -0.70$, we can see ‡‡ that it is essentially a one-pole contribution and that its trajectory is strikingly similar to that of the π_c, as determined from the conspiring $F_3^{(-)}$ amplitude ‡‡‡. In fig. 1b there are also reported the two-pole fits to the curves, fixing one of the poles to have the π_c trajectory; we find that the contribution of the other pole, to be interpreted as the A_2, is rather small and changes sign between $t = -0.45$ and $t = -0.70$.

In fig. 2a we report $\xi(\alpha_{A_2})\beta_{A_2}$ and $\xi(\alpha_{\pi_c})\beta_{\pi_c}$ (where $\xi(\alpha) \equiv (\alpha/\sin\frac{1}{2}\pi\alpha)(2M\nu_{max}/s_0)^{\alpha}$) as a result of

‡ We would also observe that all these fits assume that only A_2 is relevant in η production. This is justified by the small polarization observed in this process: $\langle P\rangle = +2 \pm 7\%$ at 11.2 GeV/c, averaged over the range $0.02 \leqslant -t \leqslant 0.35$ (GeV/c)^2 [10]; however, a non-negligible weight of the π_c cannot be excluded. Obviously this last possibility could contemplate higher values for the A_2 trajectory.

‡‡ Disregarding the deviations for points at small γ, which receive relevant contributions from the rather uncertain region near threshold.

‡‡‡ $\alpha_{\pi_c}(t) = -0.013 + 1.56\,t$, [2].

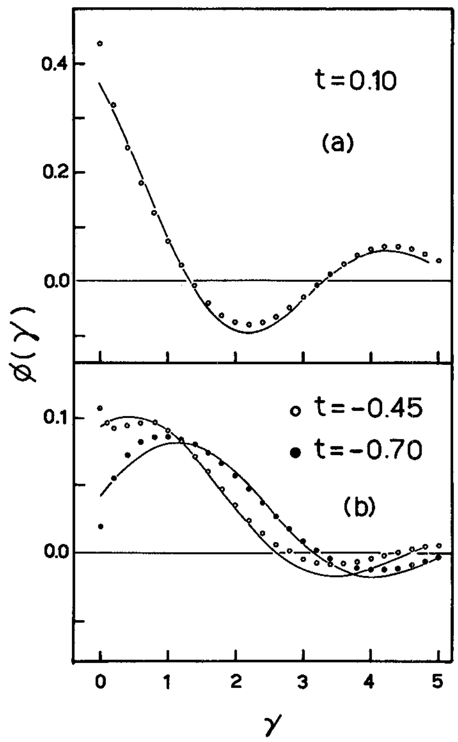

Fig. 1. a) The discrete points represent $\phi(\gamma)$ (see eq. (1)) at $t = 0.10$ and the continuous curve is its one-pole fit.
b) The discrete points represent $\phi(\gamma)$ at $t = -0.45$ and $t = -0.70$. Continuous lines are two-pole fits to $\phi(\gamma)$ with one of the two poles (the π_c) constrained to have $\alpha = -0.013 + 1.56\,t$.

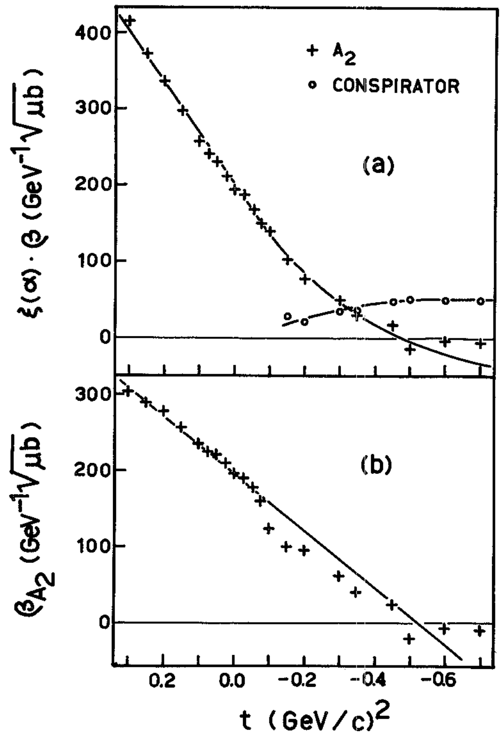

Fig. 2. a) $\xi(\alpha_{A_2})\beta_{A_2}$ and $\xi(\alpha_{\pi_c})\beta_{\pi_c}$ determined from fits to $\phi(\gamma)$ (see the text).
b) $\beta_{A_2}(t)$ resulting from the assumption $\alpha_{A_2} = 0.3 + 0.65\,t$.

the above-mentioned two-pole fit for $0.15 \leqslant -t \leqslant 0.70$. The reported values of $\xi(\alpha_{A_2})\beta_{A_2}$ for $-t < 0.15$ have been determined from a one-pole fit to the curves. In fig. 2b we report $\beta_{A_2}(t)$ as results assuming $\alpha_{A_2}(t) = 0.40 + 0.65\,t$, as given in ref. 9. The obtained form of $\beta_{A_2}(t)$ is, however, largely independent of this assumption, especially in the region where α_{A_2} vanishes. From fig. 2b one can clearly realize that β_{A_2} vanishes somewhere between $t = -0.40$ and $t = -0.6$. Associating this vanishing with the presence of an α factor in the residue, one can conclude that the A_2 chooses the Chew or the non-compensating mechanism. On the other hand, the absence of a dip in η production strongly favours the Chew mechanism over the non-compensating one.

The vanishing of the A_2 contribution allows to see clearly the π_c, and this new evidence found for its existence is perhaps the most interesting result of the $F_1^{(-)}$ analysis.

We would briefly discuss here now the presence of this Regge pole matches the known meson-resonance spectroscopy.

The doublet structure of the A_2 resonance has been confirmed in the recent experiment by Crennell et al. [6]. If both peaks have the same quantum numbers (which seems to be compatible with experiments), the system of the A_2 and π_c trajectories would provide a natural explanation for the doublet. However, one cannot, as usual, extrapolate by straight lines the two trajectories to the $t \gtrsim 1$ $(\mathrm{GeV}/c)^2$ region in order to predict the masses. In fact, as one may see from fig. 3a, there is a delicate problem of *trajectory crossing* around $t \approx 0.5$ $(\mathrm{GeV}/c)^2$, which causes deviations from linear behaviour for the two trajectories. On the other hand, the presence of a curvature in the A_2 trajectory, necessary to match the Regge fit to production with the A_2 mass, is a well-known fact (see, for instance, ref. 9). Obviously, the whole matter needs further clarification.

The π_c characteristics also provide a suggestive classification for the A_1. We shall indeed give here some arguments to identify the A_1 with the pion daughter. When $\alpha = 0$ ($t_0 \approx 0.008$), the π_c chooses nonsense [1,2]. Therefore it needs a compensating trajectory with $\alpha = -1$ at $t = t_0$. Because of the conspiracy of the pion and the π_c at $t = 0$ and the smallness of t_0, the pion daughter has just an α around -1 for $t = t_0$ and the right quantum numbers to be the necessary compensating trajectory. We assume that this is just the case. Then from $\alpha_{\mathrm{daugh.}}(0) = \alpha_\pi(0) - 1 = \alpha_{\pi_c}(0) - 1$ and $\alpha_{\mathrm{daugh.}}(t_0) - 1$ it follows that the pion daughter and the conspirator trajectories are parallel in the region near $t = 0$ (see fig. 3b) [11]. Now, since the pion daughter has no problem of trajectory crossing, it seems reasonable to assume for her a linear behaviour up to the resonance region. If one does so, one crosses $\alpha = 1$ for $\sqrt{t} = 1130$ MeV ‡‡‡, while $M_{A_1} = 1070$ MeV with a width of 80 MeV.

We would also note that one can also accommodate on the same trajectory the A_3, supposing that it has $J^P = 3^+$. In fact, this trajectory crosses $\alpha = 3$ at $\sqrt{t} = 1600$ MeV while $M_{A_3} = 1650$ MeV with $\Gamma_{A_3} = 110$ MeV. This is an alternative to the suggestion of Lubatti [12] to consider the A_3 as the $J^P = 2^-$ recurrence of the pion trajectory: taking $\alpha'_\pi(0) = 0.65$ (as determined in ref. 2) one gets $\alpha_\pi = 2$ for $\sqrt{t} = 1760$ MeV, which is reasonable.

Conclusion. More direct evidence for the existence of the pion conspirator has been provided. Moreover, it has been shown that it is not a troublesome object but is rather well integrated in the existing Regge "panorama". It can provide a natural explanation for the doublet structure of the A_2 resonance and its characteristics seem to suggest the A_1 as a recurrence of the first pion daughter. Also the A_3 can be accommodated as a further recurrence of this same trajectory; there are, however, other possibilities and, for a definite choice, a determination of its angular momentum is necessary.

As a by-product we have provided some evidence for A_2 choosing the Chew mechanism at $\alpha = 0$.

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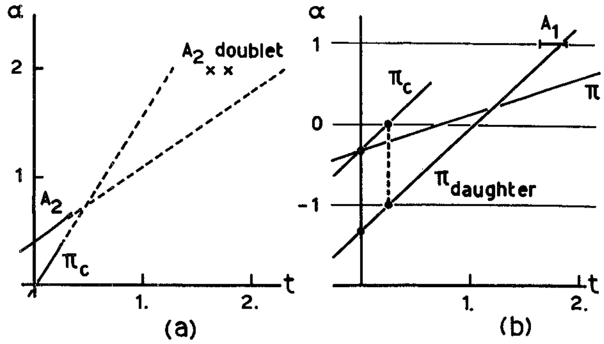

Fig. 3. a) Crossing of A_2 and π_c trajectories.
b) See the text (for the sake of clarity the trajectories are only schematic).

‡‡‡ See footnote on previous page.

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