SEARCH FOR FOUR-QUARK STATES IN TWO-PHOTON COLLISIONS AT ARGUS.

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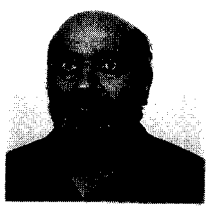

ABSTRACT.

New ARGUS results on two exclusive final states produced in two-photon interactions are presented. Angular distributions of the vector meson pairs $\rho^+\rho^-$ and $\rho^0\rho^0$ have been measured and partial wave analysis has been performed. The results are compared with theoretical models. It is concluded that the available models describe the data only qualitatively, especially when one considers ARGUS data on all the possible vector meson pairs constructed from the the lowest 1^- vector nonet.

1. Introduction.

Two-photon physics occupies only a small part of the extensive physics program of ARGUS [1], and is pursued by even a smaller fraction of the physicists in the collaboration. Nevertheless, several very interesting measurements have been performed. One field is the study of vector meson pair production, where first measurements have been published on the production of $\omega\rho^0$ [2], $\omega\omega$ [3], $K^{*0}\ \bar{K}^{*0}$ [4], $K^{*+}\ K^{*-}$ [5] and $\rho^+\rho^-$ [6]. Upper limits have been established for $\rho^0\phi$, $\omega\phi$ and $\phi\phi$ [4, 7]. In conjunction with the measurements of the angular distributions and partial wave analysis of the $\rho^+\rho^-$ and $\rho^0\rho^0$ channels presented here, ARGUS has provided data on two-photon production of all the nine possible pairs of vector mesons which belong to the lowest mass nonet and are built from the u, d and s quarks.

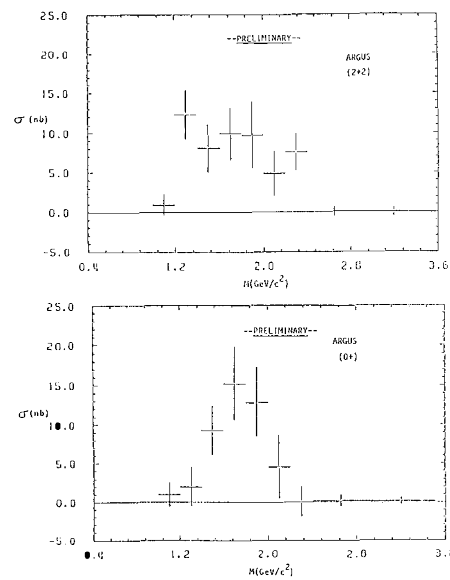

Figure 1. *Cross section for dominant partial waves in $\gamma\gamma \rightarrow \rho^+\rho^-$.*

2. $\gamma\gamma \rightarrow \rho^+\rho^- \rightarrow \pi^+\pi^-\pi^0\pi^0$.

Restricting the $\rho^+\rho^-$system to the lowest orbital angular momenta, six independent amplitudes arise: $J^P = 0^+, 0^-, 2^+$ (with helicities 0 and 2) and 2^- (with S=1 and 2). Together with the fractions for the $\rho^\pm\pi^\mp\pi^0$ and the non-resonant 4π channels, we get 8 free parameters. The fit employed a maximum likelihood technique developed by TASSO [8] for the $\pi^+\pi^-\pi^+\pi^-$ state. This maximum likelihood technique used the full event information in contrast to the method of extracting the channel probabilities from fits to two dimensional invariant di-pion mass plots.The cross sections for the dominant partial waves for $\rho^+\rho^-$ are shown in figure 1. It is clear that there is considerable activity in both the $(2^+, 2)$ and 0^+ states.

3. $\gamma\gamma \to \rho^0\rho^0 \to 2\pi^+2\pi^-$.

The analysis follows same lines as in section 2. There is one less J^P amplitude, the $2^-(S=2)$, for the $\rho^0\rho^0$ channel. The cross sections for the dominant J^P states are shown in figure 2. Once again it is clear that there is considerable activity in both the $(2^+,2)$ and 0^+ states. The cross sections are roughly a factor of four larger than the corresponding ones in the $\rho^+\rho^-$ channel. It is too premature to speculate whether the structure in the $(2^+,2)$ state is a resonance, even more so as to whether it is one of the much sought after $q\bar{q}q\bar{q}$ states.

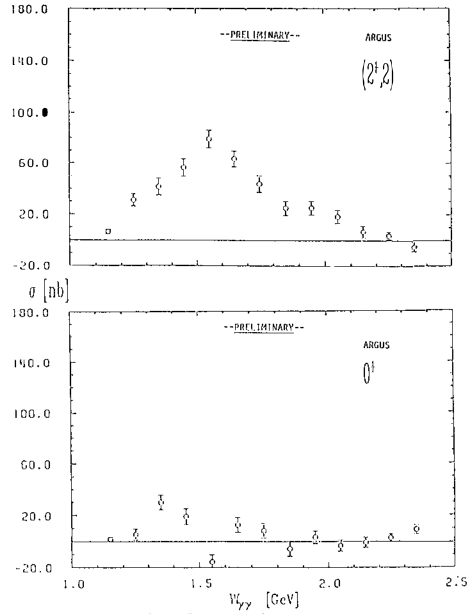

Figure 2. *Cross section for the dominant partial waves in $\gamma\gamma \to \rho^0\rho^0$*

4. Relevance to the Four-Quark Model.

Historically, a very strong threshold enhancement in the cross section for $\gamma\gamma \to \rho^0\rho^0$, first observed by TASSO [8], could not be explained by contributions from known resonance production and the Vector Dominanace Model. This stimulated a flurry of theoretical activity. Models invoking exotic objects built from two quarks and two anti-quarks, so called $q\bar{q}q\bar{q}$ states, were able to describe the $\rho^0\rho^0$ cross section. The two-photon production of a $q\bar{q}q\bar{q}$ state is expected to occur via the VDM coupling of the photons to vector mesons (ρ^0, ω and ϕ), which in turn react. A bag model [9] serves as input for the $q\bar{q}q\bar{q}$ state properties. Several $q\bar{q}q\bar{q}$ multiplets are predicted, but not all states can be produced in collisions between two transversely polarized photons. The most significant properties of $q\bar{q}q\bar{q}$ states are that isospin 0 and 2 states are allowed, and that the dominant ('fall apart' or OZI 'super-allowed') decay mode is into a pair of vector mesons. Some states are degenerate in mass, so that interference effects are expected. Two $q\bar{q}q\bar{q}$ models [10,11] have derived cross sections for all the nine possible vector meson pairs. The most dramatic qualitative prediction was that the I = 0 and I = 2 amplitudes would interfere destructively in the $\rho^+\rho^-$ channel. The measurement of the production cross section of $\gamma\gamma \rightarrow \rho^+\rho^-$ confirmed this qualitative prediction - the quantitative questions about the mass, the width and even the number of resonances were not settled. The partial wave analyses reported here unfortunately still do not settle these questions. While it is extremely difficult to 'explain' the structures in the dominant $J^P = (2^+,2)$ and 0^+ partial waves using alternative interpretations inspired by Factorization [12,13] or QCD [14], it should be pointed out that the very low upper limit set by ARGUS [7] on $\gamma\gamma \rightarrow \phi\phi$ production is a serious embarrassment for the Four-Quark enthusiasts.

Acknowledgements.

Lack of space prevents me from discussing results from CELLO, PLUTO, TASSO and TPC/2γ collaborations which confirm and extend the ARGUS results on vector pair production - my sincere apologies to colleagues from those collaborations. It is a pleasure to thank Lucien Montanet, Tran Van Thanh, Christian Voltolini and their colleagues for organizing an excellent conference. I am grateful to Bojan Bostjancic, Ken Mclean, Alf Nilsson and George Tsipolitis of the ARGUS two-photon subgroup for stimulating discussions.

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