Are the reactions $\gamma\gamma \to VV'$ a challenge for the factorized Pomeron at high energies?

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We would like to point to the strong violation of the putative factorized Pomeron exchange model in the reactions $\gamma\gamma \to VV'$ in the high-energy region where this model works fairly well in all other cases. [S0556-2821(99)01821-4]

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The factorized Pomeron exchange model is one of the most well-grounded and good working phenomenological models in high energy physics. Currently this model is particularly used in analyses of the DESY ep collider HERA and CERN e^+e^- collider LEP2 data on γp and $\gamma\gamma$ interactions (see, for example, Refs. [1–5]).

About five years ago, immediately after the ARGUS observation of $\gamma\gamma \to \rho^0\phi$ [6], we intended to publish a work entitled ''Is the reaction $\gamma\gamma \to \rho^0\phi$ a challenge for the factorization model at high energies?'' As a result, there appeared the paper: ''Estimate of $\sigma(\gamma\gamma \to VV')$ at high energies'' [7], in which, on the basis of the factorization model, the cross section for the reaction $\gamma\gamma \to \rho^0\phi$ was estimated in the range $11.5 \leqslant W_{\gamma\gamma} \leqslant 18.4$ GeV (where $W_{\gamma\gamma}$ is the $\gamma\gamma$ center-of-mass energy): $\sigma(\gamma\gamma \to \rho^0\phi) = (1.2\text{–}2.4)$ nb. We obtained the estimate taking into account all possible combinations of the existing sets of the data on the reactions $\gamma p \to \rho^0 p$ and $\gamma p \to \phi p$, in the incident photon laboratory energy range from 70 to 180 GeV, in the factorization relation for the $\gamma\gamma \to \rho^0\phi$, $\gamma p \to \rho^0 p$, $\gamma p \to \phi p$, and $pp \to pp$ cross sections [7]. A comparison of this estimate with the ARGUS data, $\sigma(\gamma\gamma \to \rho^0\phi) = (0.16 \pm 0.16)$ nb for $3.25 \leqslant W_{\gamma\gamma} \leqslant 3.5$ GeV, has shown that between 3.5 and 11.5 GeV the $\gamma\gamma \to \rho^0\phi$ reaction cross section can increase by an order of magnitude. Nothing of the kind has yet occurred in elastic and quasielastic reactions with the Pomeron exchange and with particles involving light quarks. Therefore, such an unusually strong rise of $\sigma(\gamma\gamma \to \rho^0\phi)$ expected from the factorization model and from the ARGUS data would be essentially a real challenge for our current ideas about the dynamics of quasi-two-body reactions. Why is the $\gamma\gamma \to \rho^0\phi$ cross section so small near 3.5 GeV? In Ref. [7] we concluded that either we faced a new physical phenomenon in the reaction $\gamma\gamma \to \rho^0\phi$ or the ARGUS data [6] were underestimated for some reason.

In Ref. [7] we also applied the factorization model to other reactions $\gamma\gamma \to VV'(V(V') = \rho^0, \omega, \phi)$. In particular, for the $\rho^0\rho^0$ and $\rho^0\omega$ channels in the range $11.5 \leqslant W_{\gamma\gamma} \leqslant 18.4$ GeV, we obtained the following estimates: $\sigma(\gamma\gamma \to \rho^0\rho^0) = (9.9\text{–}21)$ nb and $\sigma(\gamma\gamma \to \rho^0\omega) = (1.9\text{–}3.8)$ nb. Note that the central values of our estimates for $\sigma(\gamma\gamma \to \rho^0\rho^0)$, $\sigma(\gamma\gamma \to \rho^0\omega)$, and $\sigma(\gamma\gamma \to \rho^0\phi)$ are in excellent agreement with the similar ones obtained in Ref. [3] for the other purpose.

Here we want once again to question the factorization model for the reactions $\gamma\gamma \to VV'$ in connection with the imposing data obtained by the L3 Collaboration on the reaction $\gamma\gamma \to \rho^0\rho^0$, which has been reported at the International Workshop on e^+e^- Collisions from ϕ to J/ψ in Novosibirsk [8].

Figure 1 shows the cross section for the process $\gamma\gamma \to \pi^+\pi^-\pi^+\pi^-$ measured by the L3 Collaboration in the energy range from 0.75 to 4.9 GeV [8]. For $W_{\gamma\gamma} < 2$ GeV, $\sigma(\gamma\gamma \to \pi^+\pi^-\pi^+\pi^-)$ is rather large and is strongly dominated by $\rho^0\rho^0$ production [8,9]. Let us now look at the high $W_{\gamma\gamma}$ region. For $4.5 \leqslant W_{\gamma\gamma} \leqslant 4.9$ GeV, as is clear from the L3 data shown in Fig. 1, $\sigma(\gamma\gamma \to \rho^0\rho^0)$ is certainly less than 1.5 nb. Thus, for the reaction $\gamma\gamma \to \rho^0\rho^0$ one can repeat exactly the same statements which have been done in Ref. [7] and mentioned above in connection with the data on $\rho^0\phi$ production and the factorization model prediction.

However, we now assess the situation of the factorization model as more critical. The fact is that the L3 Collaboration has already measured the rate of $\gamma\gamma \to \rho^0\rho^0$ events up to

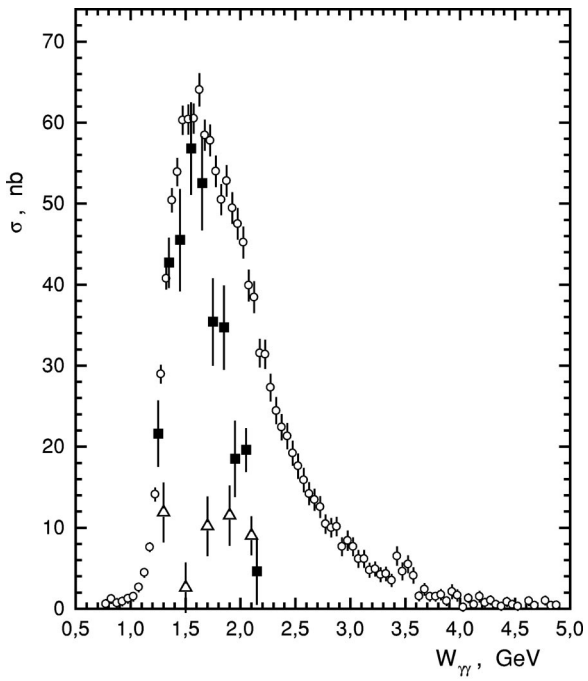

FIG. 1. The L3 preliminary data on the $\gamma\gamma \to \pi^+\pi^-\pi^+\pi^-$ cross section [8] (open circles) and the ARGUS data on the $(J^P, |J_z|) = (2^+, 2)$ partial cross section for $\gamma\gamma \to \rho^0\rho^0$ [10] (full squares) and $\gamma\gamma \to \rho^+\rho^-$ [11] (open triangles).

$W_{\gamma\gamma}=10$ GeV [5]. If the $\gamma\gamma\to\rho^0\rho^0$ cross section does not increase approximately by an order of magnitude with increasing $W_{\gamma\gamma}$ from 5 to 10 GeV, then it will signify that the factorization model for the reaction $\gamma\gamma\to\rho^0\rho^0$ is a failure in the energy region where this works fairly well in other cases.

A failure of the factorization should be expected not only in the $\rho^0\rho^0$ and $\rho^0\phi$ channels but in the $\rho^0\omega$, $\omega\omega$, $\omega\phi$, and $\phi\phi$ ones, too, because, at high energies, the reactions $\gamma\gamma\to\rho^0\rho^0$, $\gamma\gamma\to\rho^0\omega$, $\gamma\gamma\to\rho^0\phi$, $\gamma\gamma\to\omega\omega$, $\gamma\gamma\to\omega\phi$, and $\gamma\gamma\to\phi\phi$ are due to have similar mechanisms.

Thus, it may happen that either the $\gamma\gamma\to\rho^0\rho^0$ reaction cross section reaches the magnitude expected on the basis of the factorization model only at still higher energies, and there is a need to look for a specific dynamical reason for so defiant a phenomena in the formation mechanism of the Pomeron exchange for quasi-two-body reactions, or the L3 detection efficiency for the process $\gamma\gamma\to\rho^0\rho^0$, which is small at high $W_{\gamma\gamma}$ [5], has been, however, overestimated by an order of magnitude. Both of these possibilities are thus extremely important and require an immediate elucidation. However, it seems almost improbable that the same accident has occurred in measuring the two different reactions $\gamma\gamma\to\rho^0\phi$ and $\gamma\gamma\to\rho^0\rho^0$ with the two different detectors ARGUS and L3, respectively.

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[9] To illustrate this statement, we show (see Fig. 1) the data from the ARGUS Collaboration [10] on the dominant $(J^P,|J_z|)=(2^+,2)$ partial cross section of the reaction $\gamma\gamma\to\rho^0\rho^0$. In Fig. 1, we also show the ARGUS data [11] on the $(J^P,|J_z|)=(2^+,2)$ partial cross section for the reaction $\gamma\gamma\to\rho^+\rho^-$. The observed difference between the $\rho^0\rho^0$ and $\rho^+\rho^-$ production cross sections requires the presence of a flavor exotic isotensor tensor state near the nominal $\rho\rho$ threshold [N. N. Achasov, S. A. Devyanin, and G. N. Shestakov, Phys. Lett. **108B**, 134 (1982); Z. Phys. C **16**, 55 (1982); **27**, 99 (1985); N. N. Achasov and G. N. Shestakov, Usp. Fiz. Nauk **161**, 53 (1991) [Sov. Phys. Usp. **34**, 471 (1991)]; H. Albrecht *et al.*, Phys. Rep. **276**, 223 (1996); Particle Data Group, R. M. Barnett *et al.*, Phys. Rev. D **54**, 1 (1996), pp. 46, 369, 558]. An analysis of this phenomena in connection with the L3 data will be presented elsewhere.

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