*Work supported in part by the U. S. Atomic Energy Commission, Contract No. AT(04-3)-34 PA 191.

[1]A forward-backward symmetry in the longitudinal-momentum distribution of produced pions in a particular reference frame has been observed recently in π^-p interactions at an incident momenta of 25 GeV/c: J. W. Elbert, A. R. Erwin, and W. D. Walker, to be published. That interaction, however, contains inherent difficulties that might raise doubts about the validity of the results. For example, although a matter of symmetry is under discussion, and one might like to examine the distribution of a single kind of meson, the actual analysis had to be done by using negative pions for the backward distribution and positive pions for the forward distribution. The procedure is necessary in order to reduce the contribution from the incident particles (π^-,p) but it is difficult to know *a priori* how well the procedure works. These authors were, of course, aware of the problems inherent in their analysis. The virtue of the present $K^+ + p$ study is that it establishes the effect by using negative pions only, which are free of the ambiguities in the π^-p data. In doing so, it justifies the πp analysis and demonstrates that the effect is the same in both πp and Kp collisions.

[2]Lawrence Radiation Laboratory Particle Data Group, Report No. UCRL 20000 K^+N, 1969 (unpublished).

[3]We mean by "leading" particles those particles that produce a nearly uniform $d\sigma/dP_L$ distribution over a broad range of forward values of P_L in the center of mass. Generally, $d\sigma/dP_L$ falls roughly exponentially from a peak at $P_L \sim 0$. If leading particles are present, the distribution then flattens at some intermediate value of P_L and remains roughly constant out to the elastic peak. Our $d\sigma/dP_L$ distribution falls essentially exponentially at all values of P_L out to the kinematic limit. We take this to mean that leading particles are not numerous in our data.

[4]H. Satz, Phys. Rev. Lett. 19, 1453 (1967), and references therein.

[5]We are told, in fact, that an adequate fit to the separate distributions for four-, six-, and eight-prong data is possible without explicit reference to the quark model. Within the context of the multiperipheral model, the proton-meson (π or K) mass difference and the greater peripherality of the meson-proton vertex compared to the meson-meson vertex combine to produce the observed asymmetries in the center of mass. Dr. J. Friedman and Dr. C. Risk, private communication.

Phenomenology of the Background in the Resonance-Production Region*

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On the basis of the Harari-Freund hypothesis that the background in the two-body reactions can be identified with the Pomeranchuk contribution, we point out that an analysis of the background in the resonance region of inclusive reactions gives the triple Reggeon couplings involving the Pomeranchukon. This is feasible at presently available energy. Combining this with the hypothesis that the triple Pomeranchukon coupling is extremely small, we arrive at the conclusion that the background cannot be produced diffractively. This can be used to define resonances such as A_1.

The resonances have long been the focus of attention in missing-mass experiments, with the background underneath treated as somewhat of a nuisance. In this Letter we suggest that the analysis of the background in the resonance-production region at high energies can give us very important physical information.

When the c.m. energy squared, s, is much greater than the missing-mass squared, s', the scattering process $p_a+p_b \to p_c+k_1+\cdots+k_n$, where $k_1, k_2,\cdots,k_n$ are the momenta of the particles in the missing mass, can be described by a Reggeized quasi two-body amplitude corresponding to $p_a+p_b\to p_c+p_d$, $p_d = k_1+\cdots+k_n$ and $s' \equiv p_d^2$:

$$T_n(s,t,s',k_1,\cdots,k_n) \approx \sum_i \beta_i(t)(s/s')^{\alpha_i(t)}\gamma_i^{(n)}(t,s',k_1,\cdots,k_n), \quad (1)$$

where $\beta_i(t)$ is the normal Regge coupling between the particles a and c and the trajectory $\alpha_i(t)$, and $\gamma_i^{(n)}(t, s'; k_1,\cdots,k_n)$ is the Regge coupling between the particle b and quasiparticle d and the trajectory $\alpha_i(t)$. Alternatively, γ_i is the amplitude for the particle b and the trajectory $\alpha_i(t)$ going to the particles $k_1, k_2,\cdots, k_n$. The signature factor is absorbed in $\beta_i(t)$.

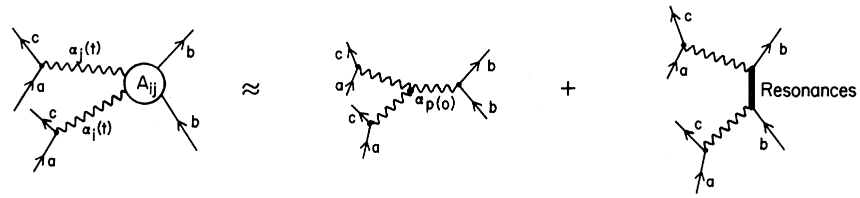

FIG. 1. Contribution of trajectories $\alpha_i(t)$ to the missing-mass spectrum in the reaction $a+b\to c+$ anything. Contribution to the absorptive amplitude A_{ij} is separated into two terms: (i) direct-channel resonances, and (ii) background, represented by crossed-channel Pomeranchuk contribution.

From Eq. (1), the differential cross section $d^2\sigma/dtds'$ is given by

$$d^2\sigma/dtds' \approx (16\pi^2 s^2)^{-1}\sum_{ij}\beta_j^*(t)\beta_i(t)(s/s')^{\alpha_i(t)+\alpha_j(t)}A_{ij}(s't), \tag{2}$$

$$A_{ij}(s't)=\frac{1}{2}\sum_n\int\frac{d^3k_1}{(2\pi)^3 2\omega_1}\cdots\frac{d^3k_n}{(2\pi)^3 2\omega_n}(2\pi)^4\delta^4(k_1+\cdots+k_n-p_d)$$
$$\times\gamma_j^{(n)}(t,s',k_1,\cdots,k_n)^*\gamma_i^{(n)}(t,s',k_1,\cdots,k_n). \tag{3}$$

Note that the differential cross section $d^2\sigma/dtds'$ is related to the usual invariant cross section $E_a d^2\sigma/d^3p_a$ by

$$E_a d^2\sigma/dp_{a\parallel}d(p_{a\perp}^2)=sd^2\sigma/dtds'.$$

$A_{ij}(s't)$ can be considered to be the absorptive amplitude of the Reggeon particle scattering $\alpha_i(t)+p_b\to\alpha_j(t)+p_b$ at vanishing momentum transfer (see Fig. 1).

We assume that $A_{ij}(s't)$ Reggeizes in a way similar to the normal two-body absorptive amplitudes, and that the same duality hypothesis of Harari and Freund applies.[1] The amplitude A_{ij} then consists of resonance terms with the Pomeranchuk exchange term as the background,

$$A_{ij}(s',t)=\eta_{ijP}(t)\beta_P^{bb}(0)s'^{\alpha_P(0)}+B_{ij}, \tag{4}$$

where $\alpha_P(0)$ is the intercept of the Pomeranchuk trajectory, $\beta_P^{bb}(0)$ is the normal Regge coupling between the particles b, b, and the Pomeranchuk trajectory; and $\eta_{ijP}(t)$ is the triple Regge coupling between $\alpha_i(t)$, $\alpha_j(t)$, and $\alpha_P(0)$. The term B_{ij} is the resonance contribution to A_{ij} in Breit-Wigner form. Equations (2) and (4) are depicted in Fig. 1. Combining Eqs. (2) and (4), we see that a detailed analysis of the background will yield the triple Regge coupling $\eta_{ijP}(t)$ involving the Pomeranchukon.

To be specific, let us consider the reaction $\pi^-p\to\pi^-X$. In addition to the leading contribution from the Pomeranchuk trajectory $\alpha_P(t)$, there can be contributions from secondary trajectories $\alpha_S(t)$ with effective intercept $\alpha_S(0)\approx\frac{1}{2}$. Equation (2) becomes

$$d^2\sigma/dtds'=|\beta_P^{ac}(t)|^2(s/s')^{2\alpha_P(t)-2}[\eta_{PPP}(t)(s')^{\alpha_P(0)-2}\beta_P^{bb}(0)+B_{PP}]$$
$$+2\,\mathrm{Re}\{\beta_S^{ac}(t)^*\beta_P^{ac}(t)\}(s/s')^{\alpha_P(t)+\alpha_S(t)-2}[\eta_{PSP}(t)(s')^{\alpha_P(0)-2}\beta_P^{bb}(0)+B_{PS}]$$
$$+|\beta_S^{ac}(t)|^2(s/s')^{2\alpha_S(t)-2}[\eta_{SSP}(t)s'^{\alpha_P(0)-2}\beta_P^{bb}(0)+B_{SS}]. \tag{5}$$

We see from Eq. (5) that in general the relative magnitude of a resonance to the background underneath varies with energy. The detail of the variation depends on the relative strength of the various couplings in Eq. (5). Let us consider two extreme possibilities: First, $\eta_{PPP}(t)\approx 0$ and B_{PP} finite; then the background will disappear, while for small t the resonance remains relatively constant. Second, if only one of the three terms in Eq. (5) survives, then the relative magnitude of the resonance to the background underneath it will not change with energy.

Recently in their attempts to understand the Pomeranchuk trajectory in dynamical models, Chew *et al.*[2] have been led to the conclusion that the triple Pomeranchuk coupling is extremely small as compared to the other couplings, and that the small parameter $\eta_{PPP}(0)$ is correlated to the small displacement of the Pomeranchuk intercept $\alpha_P(0)$ below 1. In what follows we shall accept this hypothesis and investigate its consequences. The processes in which a Pomeranchukon can be exchanged, like $\pi^-p\to\pi^-X$ and $pp\to pX$, belong to the first category mentioned above, and we expect that the backgrounds fall drastically

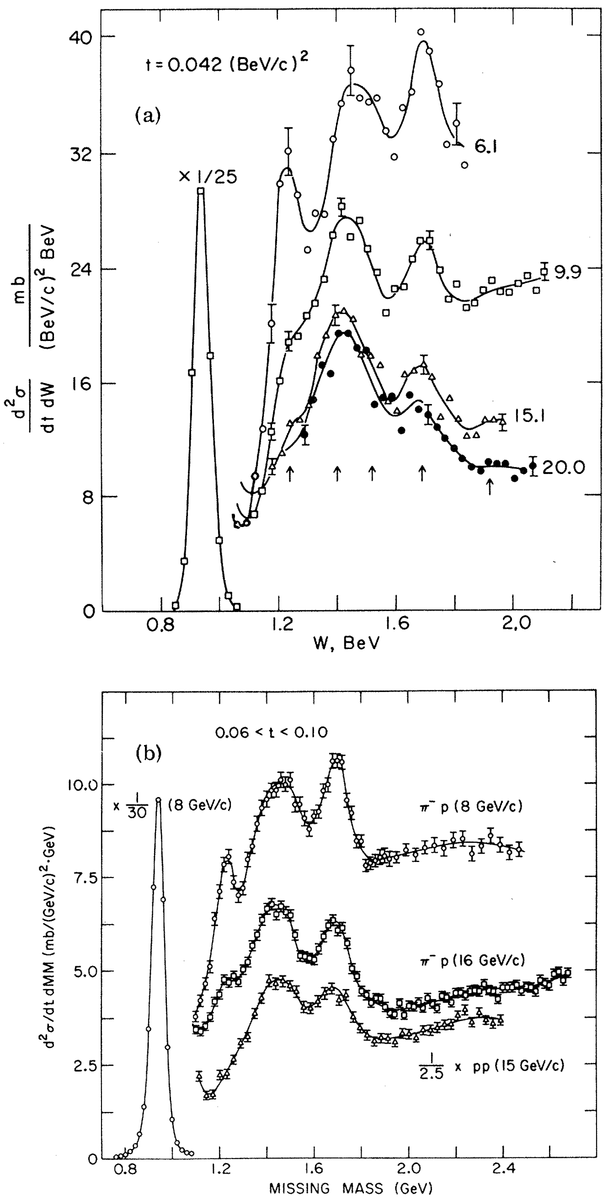

FIG. 2. (a) Missing-mass distributions $d\sigma/dt\,d(s')^{1/2}$ for $pp \to p$ + anything at 6.1, 9.9, 15.1, and 20.0 GeV/c (Ref. 4). (b) Missing-mass distributions $d\sigma/dt\,d(s')^{1/2}$ for $\pi^- p \to \pi^-$ + anything at 8 and 16 GeV/c (Ref. 3).

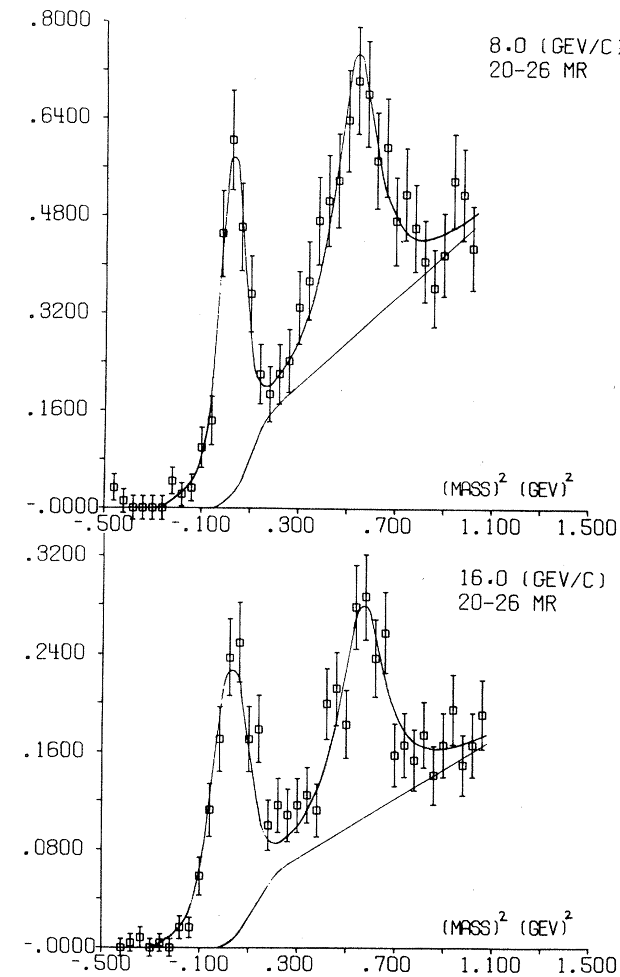

FIG. 3. Missing-mass distribution $d\sigma/d(s')d\Omega_{\rm lab}$ backward reaction $\pi^- p \to p$ + anything at 8 and 16 GeV/c (Ref. 5).

while the diffractively pr^duced resonances remain roughly constant as the energy increases. The experimental results confirm this expectation. We show in Fig. 2 the missing-mass spectra for $\pi^- p \to \pi^- X$ and $pp \to pX$ taken from Anderson *et al.*[3,4] By doing a Breit-Wigner fit to these data, the authors of Refs. 3 and 4 obtain the results[3-5] that the diffractive production cross sections of the resonances remain roughly constant, while the background cross sections decrease with increasing beam momentum p like p^{-n}, where for $pp \to pX$, $n = 1.01 \pm 0.2$ at $(s')^{1/2} = 1.4$ GeV and $n = 1.13 \pm 0.1$ at $(s')^{1/2} = 1.69$ GeV, and for $\pi^- p \to \pi^- X$, $n = 0.7 \pm 0.1$. In Fig. 3 we present the spectra for backward production $\pi^- p \to pX$. This is a relatively clean reaction since the Pomeranchuk trajectory $\alpha_P(t)$ does not contribute. In this case there is no reason for $\eta_{\Delta\Delta P}(t)$ to be extremely small, and we see indeed that the background does not decrease relative to the resonances. With more data of this kind, one should be able to determine the magnitudes of the triple Regge coupling. A rough estimate[6] shows that the spectra given in Fig. 2 are consistent with $\eta_{PPP} = 0$.

Finally, we conclude with two remarks: (1) To the extent that the triple Pomeranchuk coupling η_{PPP} can be neglected, only resonances can be produced diffractively. The background underneath them will be disappearing as energy increases until only the very small triple Pomeranchuk contribution is left. This criterion may help to determine if peaks like A_1 and Q are resonances. They are resonances if their total production cross sections can be shown to reach a constant. (2) The estimation of the triple Regge couplings and the confirmation of the smallness of the triple Pomeranchuk coupling can be carried out by analyzing missing-mass experiments at the presently available machine energy. Of course, conventional missing-mass experiments at wider and higher ranges of energies can improve the estimates.

We would like to thank Dr. Frank Turkot and Dr. H. R. Blieden for most helpful discussions on the experimental data. We thank our colleagues at The Institute of Theoretical Physics and at Brookhaven National Laboratory, in particular, Dr. Chan Hong-Mo and Dr. A. H. Mueller, for stimulating discussions.

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[1]H. Harari, Phys. Rev. Lett. 20, 1395 (1968); P. G. O. Freund, Phys. Rev. Lett. 20, 235 (1968).

[2]G. F. Chew, in Proceedings of the Eighth Coral Gables Conference on Symmetry Principles at High Energies, University of Miami, 1971 (unpublished); A. H. Mueller, *ibid.*; H. D. I. Abarbanel, G. F. Chew, M. L. Goldberger, and L. M. Saunders, Phys. Rev. Lett. 26, 937 (1971); C. S. Detar, C. E. Jones, F. E. Low, J. H. Weis, J. E. Young, and C.-I Tan, Phys. Rev. Lett. 26, 675 (1971).

[3]E. W. Anderson *et al.*, Phys. Rev. Lett. 25, 699 (1970).

[4]E. W. Anderson *et al.*, Phys. Rev. Lett. 16, 855 (1966).

[5]E. W. Anderson *et al.*, Phys. Rev. Lett. 22, 102 (1969).

[6]We thank Dr. Frank Turkot for providing us with the information of the energy dependence of the background cross section for the reaction $pp \to pX$.

ERRATA

AXIAL-CURRENT DIVERGENCES AND THE REACTIONS $\gamma + \gamma \to$ PIONS. R. Aviv, N. D. Hari Dass, and R. F. Sawyer [Phys. Rev. Lett. 26, 591 (1971)].

In Eq. (10), I^0 should be replaced by Γ^0. In the paragraph following, $s = 4\mu^2$ should be replaced by $s = (4\mu)^2$.

"RELATIVISTIC" PROPERTIES OF FLUXOIDS IN HIGH-SPEED MOTION IN SUPERCONDUCTORS NEAR ZERO TEMPERATURE. M. Sugahara [Phys. Rev. Lett. 26, 632 (1970)].

The following misprints should be corrected. In Eq. (10), $(1/r')(d/dr')a^2$ should read $(1/r')(d/dr') - a^2/r'^2$. In Eq. (13) the square bracket should appear before $+(H^2 - E^2)/8\pi$ rather than after it.

FIELD-DEPENDENT CENTRAL-CELL CORRECTIONS IN GaAs BY LASER SPECTROSCOPY. H. R. Fetterman, David M. Larsen, G. E. Stillman, P. E. Tannenwald, and Jerry Waldman [Phys. Rev. Lett. 26, 975 (1971)].

On page 976, before the heading *Experiment*, the following paragraph should have appeared:

"Kaplan[6] attempted to observe the field dependence of absolute central-cell shifts in shallow donors in InSb. He found small discrepancies between the theoretical and observed magneto-optical donor spectrum, but he was unable to demonstrate unambiguously the origin of his discrepancies."

In the caption of Table I, the following sentence was omitted:

"D_C is the deviation of measured from calculated transition energy of donor C."