We present here the cross section of the reaction $Si^{28}(\gamma, n)$ measured with the 36-MeV betatron of the Moscow University Nuclear Physics Institute. The photoneutron yield curve was obtained with apparatus comprising a paraffin sphere of 80 cm diameter containing 80 proportional BF_3 counters. The apparatus drift was suppressed by automatically switching over the maximum energy $E_{\gamma\ max}$ after each betatron operating cycle [3] and recording the reaction yield corresponding to each $E_{\gamma\ max}$ in a corresponding channel of a multichannel computing system. The yield curve was measured in the interval 17.5 - 30.0 MeV. The statistical errors in the upper part of the curve were smaller than 0.1%.

The data obtained are shown in the figure. The cross-section curve has five clearly pronounced maxima at 18.8 ± 0.1, 19.8 ± 0.1, 20.9 ± 0.1, 27.4 ± 0.2, and 28.8 ± 0.2 MeV. The first three maxima agreed extremely well with tha data obtained in [4] with a quasimonochromatic γ-quantum beam. However, the resolution of the maxima is better in our case than in [4]. The last two maxima, at 27.4 ± 0.2 and 28.8 ± 0.2 MeV, were obtained for the first time. Thier integral cross section is almost 50% of the cross section of the main maxima (18 - 22 MeV). They apparently correspond to "high-energy" transitions; in other words, in the photodisintegration of Si^{28} we encounter a clearly pronounced configuration splitting of giant dipole resonance.

[1] G. Yacob and Th. A. Maris, Rev. Mod. Phys. 38, 121 (1966).

[2] V. G. Neudachin and V. G. Shevchenko, Phys. Lett. 12, 18 (1964).

[3] O. V. Bogdankevich, Atomnaya energiya 12, 198 (1962).

[4] Y. T. Caldwell, R. R. Harvey, R. L. Bramblett, and S. C. Fultz, Phys. Lett. 6, 213 (1963).

QUARK MODEL OF BACKWARD SCATTERING

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It is known that elastic π^+p and π^-p scattering at high energies has a peak near 180° [1-3].

It was indicated earlier [4] that from the point of view of the quark model the peak in the elastic meson-baryon backward scattering (and also in some inelastic meson-baryon reactions) can be interpreted qualitatively as the result of quark exchange between colliding particles 1).

In this note we indicate some consequences ensuing to the process of backward scattering from the quark model, and compare them with the available experimental data. We also propose some details of the model, for the purpose of obtaining quantitative relations between the cross sections of different processes.

1. If the backward-scattering peak is due to exchange of individual quarks, then the form of this peak should depend on the proper momenta of the quarks in the potential well of the meson and baryon. In this case it is natural to expect the distribution of the perpendicular momenta $p_{\perp}$ in the backward-scattering peak to depend weakly (or not at all) on the momentum of the incident particle.

This is actually observed for the narrow peak of np charge exchange (which can be regarded from this point of view as np backward scattering) [5].

The presently available experimental data on the shape of the peak in elastic $\pi^{\pm}p$ backward scattering does not contradict the constancy of the slope of the peak with varying energy. According to Orear et al. [6], if we represent the shape of the peak in the form $d\sigma/dt = \exp Bu$, then $12 < B < 20$ $(GeV/c)^{-2}$ for 4 GeV/c and $13 < B < 27$ $(GeV/c)^{-2}$ for 8 GeV/c [2)].

Attention must be called to the fact that the momenta corresponding to the widths of the peaks of $\pi^{\pm}p$ backward scattering and np charge exchange are small (of the order of 0.1 GeV/c).

2. Inasmuch as baryons should consist of quarks, and antibaryons of antiquarks, there can be no quark exchange between baryons and antibaryons, and there should therefore be no corresponding peak in baryon-antibaryon interactions.

There are no peaks near 180° according to the available experimental data on elastic $\bar{p}p$ scattering at 3 GeV/c [7] and 4 GeV/c [8].

Unlike np charge exchange [9], there is no narrow peak in the charge exchange $\bar{p}n \to \bar{n}n$.

3. Since the quark compositions of the π^+ meson, the π^- meson, and the proton are $(P\bar{N})$, $(N\bar{P})$, and (PPN) respectively, P-quark exchange should take place in π^+p backward scattering, and exchange of N-quarks, which are isotopically conjugate to P-quarks, should take place in π^-p scattering. However, either of the two P-quarks of the proton can participate in the P-quark exchange with the π^+ meson, whereas only the single N-quark of the proton can participate in the N-quark exchange with the π^- meson.

The ratio of the cross sections of elastic π^+p and π^-p scattering through 180° at 8 GeV/c amounts to ~4 [6] [3)]. From the point of view of the quark-exchange model, this value of the ratio

$$R(\pi^+/\pi^-)_{180^\circ} = \frac{d\sigma}{d\Omega}(\pi^+p)_{180^\circ} \Big/ \frac{d\sigma}{d\Omega}(\pi^-p)_{180^\circ}$$

can be explained by assuming that the elastic backward-scattering amplitude is proportional to the number of possible identical channels of pairwise quark exchange or, in the more general case, to the sum of the amplitudes of the pairwise quark exchange, and there is no interference between these amplitudes.

Such an assumption is similar to a hypothesis advanced in [12-15] and well verified experimentally, namely that the amplitudes of the apirwise quark interaction are additive at low momentum transfers.

From the assumed additivity of the quark-exchange amplitudes in 180° scattering we get, in particular, the following ratio for the cross sections of backward elastic scattering of K mesons:

$$\frac{d\sigma}{d\Omega}(K^+p)_{180°} : \frac{d\sigma}{d\Omega}(K^0p)_{180°} : \frac{d\sigma}{d\Omega}(K^-p)_{180°} : \frac{d\sigma}{d\Omega}(\bar{K}^0p)_{180°} = 4 : 1 : 0 : 0.$$

The backward-scattering ratios that follow from the additivity of the quark-exchange amplitudes do not coincide with those following from the Regge-pole theory. It is important from this point of view to measure these ratios (most of all, $R(\pi^+/\pi^-)_{180°}$) at higher energies.

4. The qualitative and quantitative considerations advanced above can be apparently applied also to inelastic two-particle processes in which unlike quarks are exchanged.

In this case, at sufficiently high energies, it is necessary, for example, to satisfy the following relations between the reaction cross sections

$$\frac{d\sigma}{d\Omega}(K^-p \to \Sigma^0\pi^0) : \frac{d\sigma}{d\Omega}(K^-p \to \Sigma^+\pi^-) : \frac{d\sigma}{d\Omega}(K^-p \to \Sigma^-\pi^+) = 4 : 1 : 0$$

when the angle between the K^- and π mesons is 180°.

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[1] Aachen-Berlin-Birmingham-Bohn-Hamburg-London-Munchen Collaboration, Phys. Lett. 10, 248 (1964).

[2] A. S. Vovenko, B. N. Gus'kov, M. F. Likhachev, A. L. Lyubimov, Yu. A. Matulenko, I. A. Savin, and V. S. Stavinskii, JETP Letters 2, 409 (1965), transl. p. 255.

[3] W. R. Frisken, A. L. Read, H. Ruderman, A. D. Krisch, J. Orear, R. Rubinstein, D. B. Scarl, and D. H. White, Phys. Rev. Lett. 15, 313 (1965).

[4] Y. Fujimoto, S. Machida, and M. Namiki, Suppl. Progr. Theor. Phys., Extra Number, 1965, p. 304.

[5] J. L. Friedes, H. Palevsky, R. L. Stearns, and R. J. Sutter, Phys. Rev. Lett. 15, 38 (1965).

[6] J. Orear, R. Rubinstein, D. B. Scarl, D. H. White, A. D. Krisch, W. R. Frisken, A. L. Read, and H. Ruderman, Phys. Rev. (in press).

[7] B. Escoubes, A. Fedrighini, Y. Goldschmidt-Clermont, M. Guinea-Moorhead, T. Hofmokl, R. Lewisch, D. R. O. Morrison, M. Schneeberger, S. De Unamuno, H. C. Dehne, E. Lohrmann, E. Raubold, P. Soding, M. W. Teuchner, and G. Wolf, Phys. Lett. 5, 132 (1963).

[8] O. Czyzewski, B. Escoubes, Y. Goldschmidt-Clermont, M. Guinea-Moorhead, D. R. O. Morrison, and S. De Unamuno-Escoubes, ibid. 15, 188 (1965).

[9] P. Astbury, G. Brautti, G. Finocchiaro, A. Michelini, D. Websdale, C. H. West, E. Polgar, W. Beusch, W. E. Fischer, B. Gobbi, and M. Pepin, submitted to Phys. Lett.

[10] S. W. Kormanyos, A. D. Krisch, J. R. O'Fallon, K. Ruddick, and L. G. Ratner, Phys. Rev. Lett. 16, 709 (1966).

[11] A. S. Vovenko, B. N. Gus'kov, T. Dobrovol'skii, M. F. Likhachev, A. L. Lyubimov, Yu. A. Matulenko, and V. S. Stavinskii, submitted to Phys. Lett.

[12] E. M. Levin and L. L. Frankfurt, JETP Letters 2, 105 (1965), transl. p. 65.

[13] H. J. Lipkin, Phys. Rev. Lett. 16, 1015 (1966).

[14] J. J. J. Kokedee and L. Van Hove, Nuovo Cimento 42, 711 (1966).

[15] J. J. J. Kokedee, Phys. Lett. 22, 88 (1966).

1) The peaks in backward meson-baryon scattering were considered earlier [4] not only in the quark model but also in the Sakata model (sakaton exchange). In the latter model, however, there should be no peak in backward $\pi^- p$ elastic scattering, and this contradicts the experimental data.

2) The distribution of the cross sections depends on $p_\perp$ and differs from the distribution in u (or in t). Near 180°, however, when $|\sin\theta| \approx |\tan\theta|$, identical slopes in the plots of the cross sections against u (or t) correspond also to identical slopes in the plot against $p_\perp$.

3) This ratio was measured also at 4 GeV/c, but at this energy the backward-scattering cross section is strongly influenced also by isobar production [10,11].

CONSEQUENCES OF THE QUARK MODEL FOR THE ANNIHILATION OF A PROTON-ANTIPROTON PAIR INTO A HYPERON-ANTIHYPERON PAIR

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We analyze in this note the consequences of the quark model for the annihilation of a nucleon-antinucleon pair into a pair of hyperons. We assume with this that the model under consideration is valid at high energies and relatively low momentum transfers, when the final hyperon is emitted in the c.m.s. in the direction of the momentum of the initial nucleon, and the antihyperon is emitted in the direction of the initial antiproton momentum.

Then the amplitudes of the processes $\bar{N} + N \to \bar{Y} + Y$ can, in the quark ideology [1], be additively made up of the $\bar{p}' + p' \to \bar{\Lambda}' + \Lambda'$ and $\bar{n}' + n' \to \bar{\Lambda}' + \Lambda'$ quark amplitudes, which are equal in magnitude (owing to isotopic invariance) and differ only in sign. In such a scheme we can attempt to take into account the moderately strong interaction in the same manner as used by Lipkin [2] for elastic scattering of hadrons, i.e., we can assume that exact SU(3) symmetry does not hold for the quark amplitudes. For the processes considered, the turning on of the moderately strong interaction does not change the results that follow.

In the quark model, the following relations hold between the cross sections for production of baryons and antibaryons belonging to octet representations of the SU(3) group:

$$\sigma(\bar{p}p \to \bar{\Sigma}^-\Sigma^-) = \sigma(\bar{p}p \to \bar{\Xi}^0\Xi^0) = \sigma(\bar{p}p \to \bar{\Xi}^-\Xi^-) = \sigma(\bar{p}n \to \bar{\Xi}^0\Xi^-) = 0 \qquad (1)$$

$$\frac{1}{9}\sigma(\bar{p}p \to \bar{\Lambda}\Lambda) = \sigma(\bar{p}p \to \bar{\Sigma}^0\Sigma^0) = \frac{1}{3}\sigma(\bar{p}p \to \bar{\Lambda}\Sigma^0) = \frac{1}{3}\sigma(\bar{p}p \to \bar{\Sigma}^0\Lambda) = \frac{1}{4}\sigma(\bar{p}p \to \bar{\Sigma}^+\Sigma^+)$$
$$= \frac{1}{2}\sigma(\bar{p}n \to \bar{\Sigma}^+\Sigma^0) = \frac{1}{6}\sigma(\bar{p}n \to \bar{\Sigma}^+\Lambda) = \frac{1}{2}\sigma(\bar{p}n \to \bar{\Sigma}^0\Sigma^-) = \frac{1}{6}\sigma(\bar{p}n \to \bar{\Lambda}\Sigma^-). \qquad (2)$$

Equations (1) are a natural consequence of the model under consideration, since it