which corresponds to the Coulomb levels of the electron-positron system with the radial quantum number equal to zero.

These formulas may be generalized to the case of particles with unequal masses by means of dimensional analysis.

Let us consider the scattering of a particle of charge ze, mass m, and momentum p before and p′ after the reaction, by a particle for which the corresponding quantities are Ze, M, P and P′. In order to determine the bound states of these particles one must, following Regge, find the asymptotic behavior of the matrix element M_λ for the scattering of these particles as $t \to \infty$. By dimensional analysis it will contain a term of the form $t^{-1}(t/\lambda)^{\beta(s)}$. Therefore in order to determine $\beta(s)$ it is sufficient to consider the infrared singularities of M_λ, which are given by Eq. (1) with F given by the expression (see [3])

$$-2zZ[F((p+P)^2)-F((p'-P)^2)] + z^2F((p-p')^2)+Z^2F((P-P')^2). \tag{9}$$

The exponent β is the coefficient of $\ln(1/\lambda)$ in this expression ($t \to \infty$):

$$\beta = -zZ\frac{\alpha}{\pi}[\varphi(s)+1] + \frac{\alpha}{2\pi}\left[(z+Z)^2\left(\ln\frac{m^2}{t}+1\right)+2Z(z+Z)\ln\frac{M}{m}\right], \tag{10}$$

$$\varphi(s) = (s-m^2-M^2)\int\limits_{(M+m)^2}^{\infty} ds'/\sqrt{k(s')}(s'-s-i\varepsilon), \tag{11}$$

$$k(s) = [s-(m-M)^2][s-(m+M)^2]. \tag{12}$$

We see that it is independent of t only in the case when the particles have opposite charges: $z = -Z$. In that case (for $z = \pm 1$) the Regge exponent is equal to

$$\alpha(s) = -1+\beta(s), \quad \beta(s) = \frac{\alpha}{\pi}[\varphi(s)+1]. \tag{13}$$

For $(m-M)^2 < s < (m+M)^2$ it is equal to

$$\alpha(s) = -1+\frac{\alpha}{\pi}\left[1+2\frac{s-m^2-M^2}{\sqrt{-k(s)}}\operatorname{arctg}\frac{s-(m-M)^2}{\sqrt{-k(s)}}\right]. \tag{14}$$

If one of the particles is at rest ($M \to \infty$) and the other has energy E and $p^2 = m^2 - E^2$, then this formula gives for $|E| < m$

$$\alpha((M+E)^2) = -1+\frac{\alpha}{\pi}\left[1+\frac{2E}{p}\operatorname{arctg}\frac{m+E}{p}\right]. \tag{15}$$

For p close to zero this expression goes over into the Sommerfeld formula accurate to terms of order $[p/(m+E)]^2$.

The method here discussed allows one to obtain the leading Regge trajectory accurate to order α, which allows one to describe the Coulomb interaction. This conclusion agrees with that of Arbusov, Logunov et al [4] to the effect that the form of the Regge trajectory accurate to low orders in the coupling constant may be obtained in the framework of field theory. The rendition, however, of finer details of the interaction requires finer methods, as has been analyzed in [5].

The authors are grateful to N. N. Bogolyubov, A. A. Logunov, and A. N. Tavkhelidze for a discussion of the questions raised here.

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[1]s, u, t denote the Mandelstam variables respectively for the direct, crossed and third channels; α is the fine structure constant, the system of units is such that $\hbar = c = 1$, the metric is such that $ab = a^0b^0 - \mathbf{a}\cdot\mathbf{b}$.

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GAMMA-QUANTUM PRODUCTION IN THE INTERACTION BETWEEN 7-BeV NEGATIVE PIONS AND NUCLEONS

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Submitted to JETP editor November 20, 1962

J. Exptl. Theoret. Phys. (U.S.S.R.) **44**, 760-763 (February, 1963)

WE have previously obtained [1] the general characteristics of inelastic π^-N interactions in a 24-

liter propane bubble chamber, accompanied by the production of at least one electron-positron pair. The energy spectrum of the gamma quanta (by e^+e^- pairs), constructed for such events in the laboratory system of coordinates (l.s.) had, in addition to the maximum that is characteristic of gamma quanta from neutral-pion decay, a non-monotonicity at $E_\gamma > 100$ MeV, which could signify the existence of other gamma-quantum sources [1]. The purpose of the present work was to study this question further, and particularly to ascertain the nature of the indicated sources [2].

The results presented below are based on an analysis of 395 inelastic interactions between negative pions and nucleons, containing 454 e^+e^- pairs. The efficiency of registration of the πN interactions and of the e^+e^- pairs was 98 per cent.

Figure 1 shows the energy distribution of the gamma quanta in the l.s. In constructing the spectrum we introduced corrections for the dependence of the gamma-quantum registration by e^+e^- pairs on the energy and on the geometrical conditions. As follows from Fig. 1, in addition to the maximum connected with the $\pi^0 \to 2\gamma$ decay, the distribution has a second maximum in the gamma-quantum energy region $E_\gamma = 250$—300 MeV. It is likewise not excluded that still another anomaly is observed in the region $E_\gamma = 500$—800 MeV of the spectrum.

As regards the maximum at $E_\gamma = 250$—300 MeV, its relatively narrow width (50 MeV) enables us to assume that it is connected with the two-particle decay of some sufficiently slow particle. If we confine ourselves here to an examination of reliably established resonances, then we have as most probable the following two types of η-meson decay: $\eta \to 2\gamma$(I) or $\eta \to \pi^0 + \gamma$(II). In this case monochromatic gamma quanta with energy 273 MeV (I) or 258 MeV (II) will be produced in the rest system of the η meson ($m_\eta = 546$ MeV/c^2 [5]). The relatively large average error in the determination of the gamma-quantum energy [3] and the small statistics do not enable us to conclude unambiguously which possibility is actually realized. It must be noted, incidentally, that the corresponding ideogram has a maximum at the value of E_γ corresponding to the $\eta \to 2\gamma$ decay. The number of gamma quanta pertaining to this process amounts to $\sim 1/_{20}$ of all the gamma quanta.

The assumption that the occurrence of the second maximum is connected with the decay of the η meson into two gamma quanta is in agreement with the previously advanced considerations in favor of assuming that the η meson has quantum numbers 0^{-+} [6-8]. At the same time it must be indicated that the η-meson decay in accordance with the $\eta \to \pi^0 + \gamma$ scheme raises serious objections as considered, for example, by Gatto [9].

Analogous conclusions concerning the existence of radiative decay of the η meson were obtained also by Mencuccini et al [10], and also in the paper published after the Geneva conference by Chretien et al [11] (see in addition [12]).

In order to establish other possible sources of gamma quanta, we have also searched for resonance states that decay in accordance with the $x \to \pi^+ + \pi^- + \gamma$ scheme. For this purpose we calculated the effective masses $M_{\pi\pi\gamma}$ of the indicated systems [4]. The distribution of $M_{\pi\pi\gamma}$ with account of the efficiency of gamma-quantum registration, shown in Fig. 2, does not have sufficiently clear-cut maxima. However, energy-separation of the gamma quanta shows that for $E_\gamma = 0.5$—0.8 BeV the distribution over $M_{\pi\pi\gamma}$ has a peak in the region $M_{\pi\pi\gamma} = 0.75 + 0.85$ BeV/c^2 [5] (Fig. 3), whereas for the neighboring values $E_\gamma = 0.3$—0.5 BeV and $E_\gamma = 0.8$—1.0 BeV, the distribution over $M_{\pi\pi\gamma}$ has a uniform character. Unfortunately, the small sta-

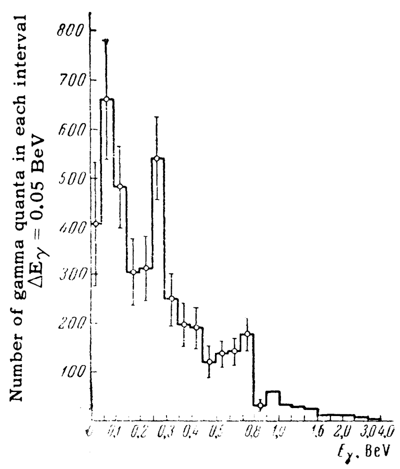

FIG. 1. Energy distribution of gamma quanta in the laboratory system.

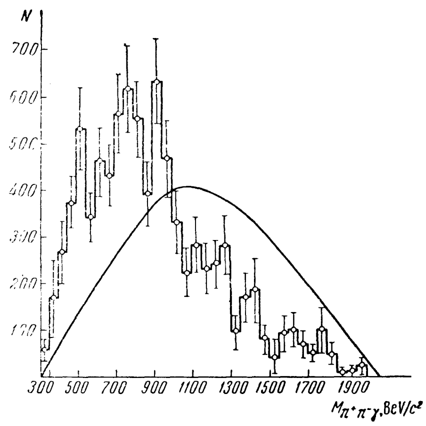

FIG. 2. Distribution of $M_{\pi\pi\gamma}$ for all πN events. The smooth curve has been calculated from the statistical theory with the aid of a table of random stars [14].

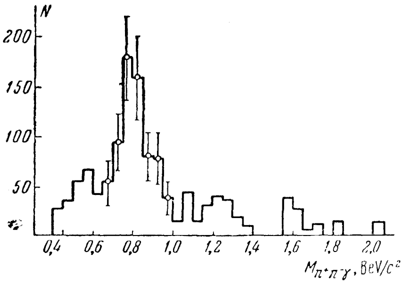

FIG. 3. Distribution of $M_{\pi\pi\gamma}$ for cases with E_γ = 0.5 – 0.8 BeV.

tistics do not enable us so far to consider this problem in greater detail.

The authors are grateful to L. B. Okun', a discussion with whom has stimulated the present work. We are grateful to V. I. Veksler for interest in the work, to V. G. Grishin and G. I. Kopylov for useful discussions and much valuable advice, and also to R. Aripov and A. I. Shklovskaya for help with the work.

The authors are grateful to the laboratory group who participated in the measurements and calculations.

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1)The corresponding kinematic considerations are developed, for example, in[2]. Analogous indications concerning the possible existence of gamma-quantum sources are contained also in[3,4].

2)The main results were reported by L. Strunov at the International Conference on High-Energy Particle Physics at CERN, in 1962.

3)In the region of the second maximum it amounts to about 10 per cent.

4)The average error in the determination of $M_{\pi\pi\gamma}$ did not exceed 5 per cent.

5)An analogous result was obtained also by another group in our laboratory[13].

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Translated by J. G. Adashko
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ON THE BOHM DIFFUSION COEFFICIENT

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Submitted to JETP editor November 21, 1962; resubmitted December 20, 1962

J. Exptl. Theoret. Phys. (U.S.S.R.) **44**, 763-765 (February, 1963)

In 1949 Bohm observed experimentally[1] that the coefficient for diffusion of plasma across a magnetic field is appreciably greater than that predicted by classical kinetic theory. He concluded that this anomalous behavior is due to an instability of unknown origin, which drives the plasma into a turbulent state, and proposed that the anomalous diffusion coefficient is given by

$$D_\perp = cT/16eH, \tag{1}$$

where H is the magnetic field, T is the plasma temperature, c is the velocity of light in vacuum and e is the charge of the electron. Since that time numerous attempts have been made to establish the nature of the instability and the resulting turbulent state, but there has been little progress toward an understanding of the anomaly (at best, through the use of additional hypotheses it has been possible to obtain numerical (!) values that approach the diffusion coefficient given above under certain conditions[2]). On the other hand, continuing experiments on plasma diffusion (see the review in [3]) frequently lead to contradictory results, some of which are in satisfactory agreement with classical theory.