[1] A. I. Akhiezer, V. G. Bar'yakhtar, and S. V. Peletminskii, JETP 35, 228 (1958), Soviet Phys JETP 8, 157 (1959).

[2] I. A. Akhiezer and Yu. L. Bolotin, Contribution the the Theory of Fluctuations and Scattering of Slow Neutrons in Ferromagnets, JETP 52, No. 5 (1967), transl. in press.

CONCERNING THE NATURE OF THE A_1 RESONANCE

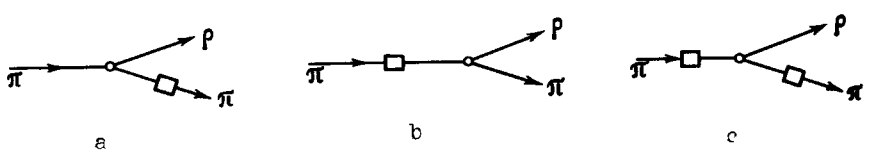
N. B. Babichev, E. D. Zhizhin, and Yu. P. Nikitin
Moscow Engineering-physics Institute
Submitted 16 January 1967
ZhETF Pis'ma 5, No. 6, 202-204, 15 March 1967

The A_1 is observed in the π-ρ system when pions interact with nucleons [1] or with nuclei [2]. The nature of this resonance has already been discussed many times in the literature. An analysis of the reaction $\pi^+ + p \rightarrow \pi^+ + \pi^- + \pi^+ + p$ on the basis of the peripheral model [3] offers evidence that the occurrence of the A_1 peak can be fully explained by scattering of a virtual pion produced as the result of the dissociation

$$\pi \rightarrow \pi + \rho \tag{1}$$

by the target proton.

We wish to call attention in this note to certain specific features of the process of diffraction dissociation (1) on nuclei, the observation of which can serve as an additional argument in favor of the diffraction mechanism for the occurrence of the A_1 peak. The dif-



ferential cross section of this process was calculated within the framework of the "black" nucleus model [4] with account of the diagrams shown in the figure. The square on the diagram corresponds to scattering of the pion by the nucleus. As shown by calculation, diagram c makes an essential contribution to the production amplitude of a ρ meson with longitudinal polarization. In spite of the fact that the wave functions of the diffracting initial and final pions differ from zero in weakly overlapping regions, the increase of the ρ-meson longitudinal polarization with increasing energy makes this diagram comparable with the corresponding contributions of diagrams a and b, and cancels them partially. In addition, in the "black" nucleus model (assuming a pointlike character of the $\rho\pi\pi$ interaction) the contributions of diagrams a and b are also partially compensated by approximately μ/m times (μ - pion mass, m - ρ-meson mass).

In the peripheral model [3], at an incident-pion energy on the order of several GeV, the main role in the dissociation (1) via the proton is played by diagram a. This is con-

nected with the fact that the energy of the virtual pion lies in the region of πN resonances, where the π-p cross section is large. With increasing energy, especially in the region where the π-p amplitude has an asymptotic form $\sim Ef(q^2)$ (E - energy of incident pion, q - momentum transferred to the nucleus), diagrams b and c must also be taken into account. In the case of dissociation (1) considered by us, in the "black' nucleus model, this is precisely the behavior of the amplitude of the scattering of the pion by the nucleus [4], as confirmed by experiment in the energy region from several GeV upward [5]. The region of applicability of the model is limited by the momentum transferred to the nucleus $q_{\parallel} \lesssim 1/R$ (R - radius of nucleus) in the direction of motion of the primary pion, and $q_{\perp} \lesssim \mu$ in the perpendicular direction. The energy threshold of the diffraction dissociation is $E_{thr} \simeq (1/2)m(m + 2\mu)R \simeq 3A^{1/3}$ GeV. In this case the momentum transfer $q_{\parallel} \lesssim 1/R$ turns out to be kinematically allowed.

The distribution over the square of the effective mass of the π-ρ system s in process (1) in the field of the nucleus, calculated on the basis of the diagrams of the figure, is

$$\frac{d\sigma}{ds} = 2 f^2_{\rho\pi\pi} q_{\perp} I_1^2(q_{\perp}R)\, dq_{\perp} \frac{1}{s^3} \sqrt{(s-m^2)^2 - 2\mu^2(s+m^2) + \mu^4}\, [1 - \tag{2}$$

$$- \frac{m^2 - 4\mu^2}{s} + \frac{(m^2 - 4\mu^2)(s - m^2)}{2s\sqrt{(s-m^2)^2 - 2\mu^2(s+m^2) + \mu^4}} \ln \frac{s - m^2 + \mu^2 + \sqrt{(s-m^2)^2 - 2\mu^2(s+m^2) + \mu^4}}{s - m^2 + \mu^2 - \sqrt{(s-m^2)^2 - 2\mu^2(s+m^2) + \mu^4}}],$$

where $f_{\rho\pi\pi}$ is the $\rho\pi\pi$-coupling constant, determined from the probability of the decay $\rho \to 2\pi$, and $I_1(q_{\perp}R)$ is a Bessel function. The distribution with respect to s has a maximum at $\sqrt{s} \simeq 1080$ MeV, corresponding to the observed mass of A_1. In the calculation we have neglected terms $\sim m/E$ and put $q_{\perp} = 0$ in the square brackets of (2), in view of the weak dependence of this expression on $q_{\perp}$ when $q_{\perp} \lesssim \mu$.

Thus, the diffraction mechanism leads to the occurrence of an A_1 peak which does not depend on the energy of the incident pion. The distribution integrated over $q_{\perp}$ is proportional to the first power of the nuclear radius R for heavy nuclei ($\mu R \gg 1$). This circumstance, together with the form of the maximum, allow us to check experimentally the validity of the assumption that the diffraction mechanism plays the dominating role. It is necessary to this end to analyze the process of A_1 production on different nuclei in the region of small momentum transfers. The total cross section of such processes is $\sigma \sim 1$ mb. (For example, $\sigma = 1.5$ mb for a nucleus with mass A = 125.)

[1] B. C. Shen, G. Goldhaber, et al., Rev. Lett. 15, 731 (1965);
G. Goldhaber, ibid. 12, 336 (1964).

[2] G. Bellini et al., Nuovo Cimento 25, 856 (1963).

[3] R. T. Deck, Phys. Rev. Lett. 13, 169 (1964);
U. Maor and T. A. O'Halloran, Phys. Lett. 15, 281 (1965).

[4] L. D. Landau and I. Ya. Pomeranchuk, JETP 24, 505 (1963); E. D. Zhizhin and Yu. P.

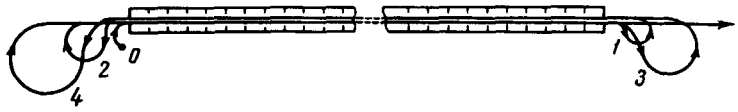
Nikitin, JETP 43, 1731 (1962), Soviet Phys. JETP 16, 1222 (1963).
[5] N. G. Birger, V. D. Mikhailov, I. L. Rozental', and L. I. Sarycheva, UFN 79, 523 (1963), Soviet Phys. Uspekhi 6, 250 (1963).

THE LINOTRON - A SHORT LINEAR ACCELERATOR

A. A. Kolomenskii
Submitted 26 January 1967
ZhETF Pis'ma 5, No. 6, 204-207, 15 March 1967

High-energy electrons are obtained either with cyclic accelerators (synchrotrons) or linear accelerators (LA). These installations are very large: the length of a LA reaches several kilometers, and the diameter of a synchrotron several hundred meters. The variability of the magnetic field causes the average beam intensity in the synchrotron to be at least two orders of magnitude smaller than in the LA. This difference becomes even sharper when cryogenic continuously operating LA are used, but the loss per unit length of cryogenic LA is much higher than that of ordinary LA. The diameter of the synchrotron is made larger to reduce the loss to synchrotron radiation and to reduce the power of the high-frequency system.

We wish to point out in this article the possibility of producing accelerating systems in which a given LA can yield energy several times larger than that for which it is nominally designed. The possible realization of such systems, which can be called for brevity linotrons, is based on the peculiarities of the particle dynamics in a LA constituting a iris-loaded waveguide. In the case of relativistic particles, the resonant accelerating wave propagates in the waveguide at constant velocity equal to the velocity of light, and the structure of the LA remains constant over the entire length. This leads to two important properties of the relativistic LA, to which due attention has not been paid so far: first, it is possible to accelerate simultaneously particles having greatly differing relativistic energies (the achromatism of LA); second, it is possible to accelerate the particles in both directions, both alternately and simultaneously (the symmetry of LA). For the symmetrical mode it is necessary to accelerate a standing wave constituting a sum of two waves traveling in opposite directions.



Schematic diagram of reciprocal linotron. 0 - injection channel, 1,2,3,4 - magnetic channels.

The achromatism and symmetry properties make it possible to extend the possible use of LA in different variants, of which we shall consider here only one - the reciprocal linotron. Assume that the end points of an LA are provided with a certain number of magnetic channels, which in general should consist of turning-focusing magnets with fields that are constant