[8] S. M. Stishov and N. A. Tikhomirova, PTE, No. 5, 251 (1965).

[1] The bismuth used was 99.999% pure.

CONCERNING THE SEARCH FOR SPECIFIC INTERACTIONS BETWEEN μ MESONS AND ν_μ NEUTRINOS AT ULTRAHIGH ENERGIES

M. Markov
P. N. Lebedev Physics Institute, USSR Academy of Sciences
Submitted 6 December 1965
ZhETF Pis'ma 3, No. 2, 98-101, 15 January 1966

In the analysis of experimental cosmic-ray data, especially data on underground neutrino experiments, an important assumption is that the muons experience only electromagnetic and weak interactions, and the ν_μ neutrino always interacts only weakly. The information gradually accumulating in cosmic-ray research may possibly offer evidence of the presence of specific muon interactions, and possibly also ν_μ neutrino interactions, which are effective essentially only at energies $E \geq 10^{12}$ eV [1-3].

By way of a model of such interactions, which increase with energy, let us consider a paseudovector (pseudo-Maxwellian) field with interaction of the type [1]

$$g(\hbar/mc)\gamma_5\gamma_\mu\gamma_\nu(\partial\mathcal{P}_\mu/\partial x_\nu).$$

Let g-charge be possessed by the muons and nucleons, and let the ν_μ neutrinos and the electrons have no g-charge, or in the case of electrons let the charge be appreciably smaller.

An analysis of the data obtained by neutrino experiments in CERN (the absence of "neutral currents," i.e., of "Compton" protons, the absence of mesic pairs from neutrinos, i.e., $\sigma_{2\mu} \leq 10^{-40} - 10^{-41}$ cm^2) shows that if the pseudophotons are at all present in the neutrino beam, the corresponding "fine structure" constant is $g^2 < 10^{-6} - 10^{-7}$. The cross section for production of pseudophotons with energy $E_\mathcal{P} \sim E_0/2$ from primary protons (E_0) could have a structure (up to proton energy $\sim 10^{15}$ eV) $\sigma_\mathcal{P} \sim \sigma_n g^2(E_0/m_n c^2)$, where σ_n is the total nucleon cross section of strong interactions. That is to say, under this assumption we have $\sigma_\mathcal{P} \lesssim \sigma_n$ for protons with energy $E_0 \sim 10^{15}$ eV and for $g^2 \sim 10^{-7} - 10^{-6}$.

The cross section for the production of μ pairs by pseudophotons in the Coulomb field of an extended nucleus with charge z can be expected to have the form

$$\sigma_{2\mu} \sim (e^2/m_\mu c^2)^2 \alpha z^2 g^2 (E_\mathcal{P}/m_\mu c^2) \sim 10^{-27} - 10^{-28} \text{ cm}^2$$

for

$$z \sim 10, \quad g^2 \sim 10^{-6} - 10^{-7}, \quad E_\mathcal{P} \sim 10^{14} \text{ eV}; \qquad \alpha = e^2/\hbar c.$$

But even for pseudophotons with energy $< 10^{12}$ eV the cross section for μ-pair production is $\leq 10^{-29} - 10^{-30}$ cm^2, the corresponding muon pairs can be produced only deep underground, imitating, in particular, the effect of an intermediate meson created by a neutrino [3,4].

In the Coulomb field of the nucleus, the muon can produce directly a muon pair. Muon pairs can be produced upon collisions of primary protons [1, 2].

Groups of μ mesons with $E_\mu \sim 10^{13} - 10^{14}$ can thus be produced in the atmosphere, in a very narrow cone, from primary protons with energies $\sim 10^{14} - 10^{15}$ eV. A somewhat different situation is produced if the ν_μ neutrino, like the muon, carries g-charge. Then, apparently, the ν_μ neutrino should have a nonzero rest mass, and should carry additional energy losses for the formation, say, of muon pairs.

The possible existence of a relatively penetrating component in cosmic rays makes ambiguous the interpretation of the results of underground neutrino experiments. It is desirable to eliminate this ambiguity.

Certain experiments are being carried out in South Africa and India [4] at somewhat different depths (8800 and 7500 m w. e.), so that the count of the events may also be different, owing to some absorption of the possible additional neutral component. Entirely different results would be obtained if the entire planet were to be used as a "shield" [5]. For concrete numerical deductions, however, further and more detailed estimates are necessary.

[1] I. L. Rozental', JETP 36, 943 (1959), Soviet Phys. JETP 9, 666 (1959).

[2] S. N. Vernov, G. B. Khristiansen, Yu. A. Nechin, O. V. Vedeneev, and B. A. Khrenov, International Conf. on Cosmic Rays, London, September 1965.

[3] T. Matano et al., Phys. Rev. Lett. 15, 594 (1965).

[4] C. V. Achar et al., Phys. Lett. 18, 196 (1965); F. Reines et al., Phys. Rev. Lett. 15, 429 (1965).

[5] M. A. Markov, Neitrino (The Neutrino), pp 79-87, Nauka, 1964.

1) Since we consider the situation within the framework of the experimental feasibility of observing such interactions, we are justified to some extent in disregarding for the time being the divergences which are unexplained in the nonrenormalizable theories.

2) An entirely different situation will arise if more refined neutrino experiments with accelerators reduce the upper limit of g^2 by one or two roders of magnitude. In this case $\mathcal{P}$ will be only of theoretical interest (for $E_\mu \sim 10^{14}$ eV), from the point of view of the mass difference between the electron and the muon.

EXPERIMENTAL DETERMINATION OF THE SPEED OF SOUND IN THE CRITICAL REGION OF CARBON DIOXIDE

Yu. S. Trelin and E. P. Sheludyakov
Thermophysics Institute, Siberian Division USSR Academy of Sciences

Submitted 13 December 1965
ZhETF Pis'ma 3, No. 2, 101-103, 15 January 1966

The published experimental data on the speed of sound near the critical point of carbon dioxide are rather contradictory. We have carried out systematic measurements of the speed of sound in the critical region of CO_2. The measurements were made at 500 cps with the apparatus described in [1,2]. The results of measurements along four isotherms, including the critical