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ON A POSSIBILITY OF SPECIFIC INTERACTIONS OF MUONS AND ν_μ -NEUTRINOS AT SUPERHIGH ENERGIES

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In analysing the data of cosmic-ray experiments and, in particular, those of underground neutrino experiments, of importance is the assumption that the muons possess only the electromagnetic and weak interactions and the ν_μ -meson neutrinos interact always only weakly. In cosmic-ray research information is being gradually accumulated which provides likely evidence for the presence of specific interactions of muons and, perhaps, of ν_μ - neutrinos, which are essentially displayed at an energy $E \geq 10^{12}$ eV. /1-3/.

As a model of such interactions increasing with energy we shall consider a pseudovector (pseudo-Maxwell) field with an interaction such as[x/]

$g \frac{\hbar}{mc} \gamma_5 \gamma_\mu \chi_\nu \frac{\partial P_\mu}{\partial x_\nu}$.

Let g be the charge of muons and nucleons. ν_μ - neutrinos and electrons do not possess the g -charge or their charge is much smaller.

The analysis of the CERN data on neutrino experiments (the absence of "neutral currents", i.e. "Compton" -protons, the absence of muon pairs, i.e. $\sigma_{2\mu} < 10^{-40} - 10^{-41} \text{cm}^2$ shows that if in the neutrino beam there are pseudophotons then the corresponding "fine structure" constant $g^2 < 10^{-6} - 10^{-7}$. The cross section for production of pseudophotons with an energy $E_p \approx \frac{1}{2} E_0$ by primary protons (E_0) might have the structure (up to photon energy $\approx 10^{15}$ eV): $\sigma_p \approx \sigma_n g^2 \frac{E_0}{m_n c^2}$ where σ_n is the total cross section for strong nucleon-nucleon interactions, i.e. under assumption for $E_0 \approx 10^{15}$ eV protons,

$$g^2 \approx 10^{-7} - 10^{-6} \quad ; \quad \sigma_p \lesssim \sigma_n \quad .$$

The cross section for muon pair production by pseudophotons in the Coulomb field of an extended nucleus of charge z may be expected in the form:

$$\sigma_{2\mu} \approx \left(\frac{e^2}{m_\mu c^2}\right)^2 \alpha z^2 g^2 \frac{E_P}{m_\mu c^2} \approx 10^{-27} - 10^{-28} \text{cm}^2 \, ,$$

if $\quad z \approx 10 \, , \; g^2 \approx 10^{-6} - 10^{-7} \, , \; E_P \approx 10^{14} \text{ eV} \, ; \; \alpha = \frac{e^2}{\hbar c}$.

But already for pseudophotons with an energy $< 10^{12}$ eV the muon pair production cross section $\sigma_{2\mu} < 10^{-29} - 10^{-30}$ cm^2 i.e. the corresponding muon pair can be produced only deeply in the earth imitating, in particular, the effect of an intermediate meson created by neutrino/4/.

In the Coulomb field the muon can directly produce a pair of muons/1,2/. The muon pairs can be created in the primary proton collisions.

Thus, primary protons of an energy $10^{14} - 10^{15}$ eV can cause in a cascade manner muon groups/2/ with $E_\mu \approx 10^{13} - 10^{14}$ eV in the atmosphere in a very narrow cone.

A somewhat different situation takes place if the ν_μ - neutrino, like the muon, carries the g - charge. Then, the ν_μ - neutrino must likely possess a rest mass different from zero and spend an additional energy for production of, e.g., muon pairs.

The possibility for a such relatively penetrating component to exist in cosmic rays leads to an ambiguous interpretation of the results of underground neutrino experiments. It is desirable to rule out this ambiguity xx/.

The well-known experiments in the South Africa and India/4/ are being made in somewhat different depths (8800 and 7500 m.w.e.), so that the counting rate of events may be somewhat different due to some absorption of a possible additional neutral component. Essentially different results might be obtained in using as the "shielding" the whole planet/5/.

But to draw concrete numerical conclusions further more detailed estimations are needed.

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x/ Considering the situation within the experimental possibilities for such interactions to be detected we have some right not to be concerned, at first, with the problems of divergences which are still open in nonrenormalizable theories.

xx/ Quite a different situation will occur if a further improvement of neutrino experiments on accelerators lower the upper limit for g^2 by one order or two. In that case the P -field will be of a theoretical interest only (for $E_\mu > 10^{14}$ eV) in the sense of the mass difference of the electron and the muon.