EXPERIMENTS WITH NEUTRINOS EMITTED BY MESONS

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Recently there were widely discussed the possibilities of using beams of high energy neutrinos emitted by mesons to get information on weak interactions.[1,2,3,4,5]

In the papers[3,4] it has been shown that the form-factors related to the presence of strong interacting particles suppress the increase with energy of the cross-sections for reactions of the type $\tilde{\nu} + p \rightarrow e^{+} + n$ at neutrino energies ~ 1 BeV.

In the discussion of experiments with high energy neutrino ($\gtrsim 1$ BeV) the problem as to whether there exists the intermediate vector B-meson has a special place, since the corresponding experiments may turn out to be feasible within a relatively short time. R.M. Ryndin and the author[6], and Lee and Yang[3], as a matter of fact, have shown that a B-boson with a mass of a few nucleon masses can be discovered in reactions of the type $\nu + Z \rightarrow B + \mu(e) + Z$, the cross-section of which is much greater than the cross-section characterizing the reactions induced by neutrinos in the case of local interaction. In[1], it was pointed out that $\tilde{\nu}_{\mu}$ of relatively low energy emitted by stopping μ^{+}-mesons may be used in order to decide whether muon (ν_{μ}) and electron (ν_{e}) neutrinos are identical particles.

Below additional arguments are given on neutrino of intermediate energy ($<$ 300MeV) which may be useful in planning experiments with neutrino beams and in designing accelerators meant for performing such experiments.

Apart from the B-meson problem and the problem of the energy dependence of the cross-sections for weak processes, the solution of which clearly demands neutrinos with very high energy, the main qualitative questions in neutrino physics are the following ones:

1. Are ν_{e} and ν_{μ} identical particles?

2. Does neutrino scattering by leptons occur as a first order process in the weak interaction constant?

From an experimental point of view, the neutrinos with intermediate energy have definite advantages in connection with the above-mentioned problems: not only their intensity (for a number of reasons) can exceed very much the intensity of very high energy neutrinos, but they can easily be obtained with very well defined energy, a circumstance allowing a kinematic interpretation of neutrino induced events.

Monochromatic sources of neutrinos may be obtained by stopping π^+, K^+ and μ^- in matter, as follows:[x)]

Neutrino source	Neutrino energy (MeV)
$\pi^+ \to \mu^+ + \nu_\mu$	29,8
$K^+ \to \mu^+ + \nu_\mu$	235,7
$\mu^- + A \to \nu_\mu + \ldots$	$\sim$ 100

It is to be noted that monochromatic ν_μ, rather than $\tilde{\nu}_\mu$ are obtained when a $\lesssim$ 1 BeV proton beam is being stopped in a block of heavy material. The moderation in the same block of the produced mesons permits, according to the Table, to obtain a spatially well localized monochromatic neutrino source. These lines of monochromatic neutrinos are, of course, accompanied by a background of a continuous spectrum, especially ν_e and $\tilde{\nu}_\mu$ from μ^+-meson decay[1)].

For example, to test whether ν_e and ν_μ are identical particles, it is possible to measure the cross-sections for the reaction $\nu_\mu + C^{12} \to e^- + N^{12}$. The energy of the electrons emitted by incident monoenergetic neutrino is known, the time at which the electrons are emitted must coincide with the time at which the neutrino is absorbed (today's electronics allows to make use of the time characteristics of the accelerator, including the cyclotron with a spatial variation of the magnetic field). Besides, it is necessary to record delayed positrons from N^{12} decay. Such an experiment can be performed with large magnetic bubble chambers or with electronic methods of registration. The counting rate is comparable with the rate expected in the experiment suggested in[(1)].

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x) The possibility of using a K-capture radioelement as a strong source of low energy ($E_\nu \sim 1$ MeV), monochromatic neutrinos, is beyond the scope of the present note. Such a possibility is attractive from the point of view of performing experiments on $(\nu_e e)$ scattering under conditions in which the kinematics of the events can be analysed. Here we wish to mention also the possibility that the answer to the question as to whether there is the $(\nu_e e)$ scattering process might be given by astrophysics.[7)]

References

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