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NEUTRINO EXPERIMENTS IN BUBBLE CHAMBERS: VECTOR MESON PRODUCTION, $\Delta S = \Delta Q$ TEST AND $\Delta S = 2$ TEST USING AN INTERFERENCE TECHNIQUE; HEAVY MUON SEARCHES

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ABSTRACT

Vector meson production by neutrinos is considered. The rates are large enough to be seen in the NAL 25-ft bubble chamber. Background will be a problem but can probably be separated out by selecting events with short proton recoils only and then selecting appropriate mass bands.

New $\Delta S = \Delta Q$ and $\Delta S = 2$ tests are proposed using $\nu n \rightarrow \mu^- K^o p$ and $\bar{\nu} p \rightarrow \mu^+ \Lambda^o K^o$ and making use of the fact that in the presence of violations of the above rules the K^o will be a mixture of K^o and $\overline{K^o}$. Hence the ratio of K_1^o to K_2^o decays will not be 1. These tests depend linearly on the amplitude of the violation component and are intrinsically more sensitive then experiments looking at ratios of violating and conserving rates, since the latter depend quadratically on the rates.

It is pointed out that if a Low-type heavy muon exists, with a standard weak-interaction coupling, searches can be made for it at NAL, sensitive up to 6 or 7 BeV.

I. VECTOR MESON PRODUCTION

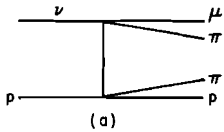
One is interested in comparing the production of vector mesons by electrons and neutrinos. This tests that the weak current is really an isotropic rotation of the electromagnetic current, i.e., that the weak and em currents are in the same octet.

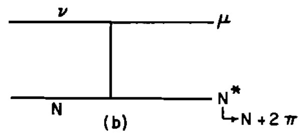
Another way of saying this is that one is looking at the ρ beta-decay coupling constant. Two estimates exist on rate[1,2] by one production mode which differ by about a factor of 5. I shall use mine, which is the lower estimate. Using the standard flux in a double chamber (14-foot hydrogen, 11-foot neon-hydrogen) one then gets:

	E_ν (GeV)	Events
$\nu + p \rightarrow \mu^- \rho^+ p$	5-10	180
$\quad \hookrightarrow \pi^+ \pi^o$	10-15	190
$\qquad \hookrightarrow 2\gamma$	15-20	90
	20-25	36

This assumes that for $E_\nu > 5$ GeV, the cross section for ρ production is 2×10^{-41} cm^2.

To observe this reaction, one must detect the gamma rays. The proton will generally have a short recoil since the process calculated may be viewed as the ν turning into a $\mu + \rho$, followed by the ρ scattering off the proton. This reaction could also be done in a neon chamber and one would gain about a factor of 5 in intensity, but about one-half the events would use neutrons as the target nucleon. The decreased measurement accuracy in neon would also make it harder to separate out the background. The background consists of events from the channels:





C. Franzinetti has estimated the rate from diagram (a) to be small, and (b) will probably be the largest background.

Experimentally, with low statistics in the propane run at CERN (~1,000 events total), no candidates for 2π production were found with a short recoil. Here we shall have about 1,000 times the rate.

The characteristics that distinguish this reaction from background are:

1. Low momentum of recoil proton
2. $\pi^+\pi^o$ effective mass in ρ band
3. Possibly helicities may be useful although rates are low.

Until the background is better known, it is hard to assess accurately the practicality of this experiment. One can probably stand a background of 10 to 100 times the signal. At this time it would appear to have a reasonable chance of success.

The cross section for A_1 is harder to estimate, but above 10 BeV it should be 1 or 2×10^{-41} cm^2, and hence the considerations are similar to those discussed above.

It has been suggested[3] that a measurement of neutral currents is possible through the reaction $\nu p \rightarrow \rho^o \nu p$. If one expects the rate to be of the same order of magnitude as the charged rate, it would appear exceedingly difficult to examine this reaction. It is a 0c fit with no muon and one must fight against a background of neutron events from neutrino induced neutrons. Since there are estimated to be more than one of these per picture, it would appear that $\nu p \rightarrow \nu \rho^o p$ cannot be distinguished experimentally unless one can discover some distinctive characteristic to eliminate neutron background which is perhaps 10^3 larger.

II. A NEW METHOD FOR $\Delta S = \Delta Q$ AND $\Delta S = 2$ EXPERIMENTS

This experiment would require a double chamber. If there is a small $\Delta S \neq \Delta Q$ component in the weak current, then in $\nu n \to \mu^- {''}K^o{''}p$, the "$K^o$" will be $K^o + y\overline{K}^o$ where y is of the order of magnitude of x in $K_{\ell 3}$ decay studies, and x is known to be $\lesssim 0.1$. The decay of the "K^o" into K_S and K_L will then not be equal, but instead $K_S/K_L \sim 1 + 4y$. This is linear in the violation parameter y while the ratio $\nu n \to \mu^- \Sigma^+ / \overline{\nu} p \to \mu^+ \Sigma^o$ goes as y^2.

Hence, one can look at the ratio of K_S to K_L events in $\nu n \to \mu^- K^o p$. The main problem is that the unseen K_L events are 0c fits. However, if the K_L goes through many feet of neon, it should interact or decay as a K_S. Hence, one should be able to get a 3c or 2c fit depending on whether the K_L decays or interacts.

Unfortunately, no experimental rates are known for K^o producing processes of γ or $\overline{\nu}$. If the rate proves large enough this may provide another $\Delta S/\Delta Q$ test, but no numerical calculations can be made at this time.

The reaction $\overline{\nu} p \to \mu^+ \Lambda^o K^o$ can be used to test for $\Delta S = 2$ in the same manner, since again the "K^o" will have a $\overline{K}^o$ component. This rate should be large enough to perform the experiment and the Λ^o signature will help in reducing background somewhat.

III. HEAVY MUON SEARCH

It has been suggested by Low that heavy muons may exist, decaying into $\mu + \gamma$. If these heavy muons are coupled into the weak current with approximately the same strength as ordinary muons (rather than α times this coupling), they could be produced in neutrino interactions by, e.g., $\nu + n \to \mu^{-*} + p$. The major background would be from $1\ \pi^o$ production. If the gamma conversion efficiency were good, many of these could be eliminated and a $\mu\gamma$ mass peak could be seen. The event rate has not been calculated but is probably large only well above threshold. A 70-BeV neutrino incident on a nucleon corresponds to about 11-1/2 BeV total center-of-mass energy, so the test would probably be sensitive up to 6 or 7 BeV mass heavy muons.

REFERENCES

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