EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

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M E M O R A N D U M

To : Physics III Committee

From : V. Soergel

Subject : Proposal from experiment on the reactions

$$\pi^+ + {}^{12}C \to \pi^0 + {}^{12}N$$

$$\pi^- + {}^{12}C \to \pi^0 + {}^{12}B$$

The ft value for the beta decay of ^{12}N to the ground state of ^{12}C is significantly larger (11 ± 1%) than the ft value for the mirror beta decay of ^{12}B [1]. This may be due to a difference in the nuclear matrix elements as proposed by Eichler et al.[2], or to contributions of G parity non-invariant terms in the weak interaction as outlined by Huffaker and Greuling[3], and by Blin-Stoyle and Rosina[4]. This type of weak interaction has not been observed up to now.

A measurement of the ratio of the nuclear matrix elements by a method which does not involve weak interactions could decide between the two ways of explaining the difference in the ft values, or give their relative contribution to the effect.

The most direct experiment would be a measurement of the magnetic moments of ^{12}B and ^{12}N ground states, as the Gamow-Teller matrix element is in this case proportional to the magnetic moment. Due to the short lifetime of ^{12}B (20 msec) and ^{12}N (10 msec), such measurements are difficult.

Another way of obtaining information on the ratio of the nuclear matrix elements is a comparison of the cross-sections for the reactions

$$\pi^- + {}^{12}C \to \pi^0 + {}^{12}B_{\text{ground state}}$$

$$\pi^+ + {}^{12}C \to \pi^0 + {}^{12}N_{\text{ground state}} .$$

As only strongly interacting particles are involved and the input channels are, apart from the Z component of isotopic spin, identical, any difference in the cross-sections must be due to a difference in the wave functions of ^{12}B and ^{12}N, provided of course that Coulomb effects on the incoming pions can be neglected. This is certainly the case if pions of reasonably high energy ($E_{\pi} \simeq 100$ MeV) are used.

The charge exchange cross-section does not have such a direct relation with the beta decay matrix element as does the magnetic moment, since besides the nucleon which is at the same time responsible for the beta decay and the magnetic moment, other nucleons may be involved in the reaction. However, there is certainly a qualitative relation in the sense that equal cross-sections would rule out the possibility of explaining the difference in the ft values by a difference in the nuclear matrix elements. A more quantitative relation can probably be found by a detailed theoretical study.

On the basis of these considerations, we intend to compare the cross-sections for the charge exchange of π^+ and of π^- on ^{12}C in an experiment to be carried out at the synchro-cyclotron. The identification of the process will probably be based on detection of the π^0 and the decay electron in delayed coincidence.

The precision which can be reached in such an experiment will, in particular, strongly depend on two points:

i) The order of magnitude of the cross-section, since it determines the statistical accuracy that can be obtained.

ii) The contribution of excited states in ^{12}B to the cross-section. ^{12}B has, besides the ground state, two particle-stable excited states at 0.95 and 1.67 MeV excitation energy, which decay into the ground state by γ-ray emission. The delayed activity will measure the charge exchange reaction leading to all three states, and the contribution of the excited states must be determined independently. The precision required for this additional measurement depends, of course, on the relative contribution of the excited states to the delayed activity. In ^{12}N, this problem does not arise, as all excited states are particle unstable.

There is, at present, no experimental information available on either one of these points.

The first point in our experimental programme will therefore be to determine the order of magnitude of the charge exchange cross-section with a rather simple set-up. For this purpose we want to study the γ-ray spectrum from inelastic scattering of pions on ^{12}C. The cross-section for the excitation of the 15.1 MeV level, which is a member of the ^{12}B, ^{12}C, ^{12}N isospin triplet, must be the same as for the charge exchange reactions leading to the ^{12}B and ^{12}N ground states. Such a measurement is probably easier and cleaner than a simple activation measurement, which would measure the charge exchange directly.

The final set-up for the charge exchange experiment will be designed according to the results of this preliminary measurement.

The whole experiment will be carried out by physicists from the University of Heidelberg in the framework of the CERN-Heidelberg group. The expenses will be paid by the University of Heidelberg.

For the preliminary measurement on inelastic scattering, about 10 shifts of main users' time and a sizeable amount of parasitic time in a pion beam, preferably the 70 MeV beam, is needed. The team could start working in April, and the main users' time will probably be asked for in May and June, this year. A request for the machine time needed for the final experiment will be presented after the preliminary run.

REFERENCES

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