Proc. Sixth Int. Symp. Polar. Phenom. in Nucl. Phys., Osaka, 1985
J. Phys. Soc. Jpn. 55 (1986) Suppl. p. 1012-1013

6.13 Limitation of the Validity of the G-Parity Conservation Law in Weak Nucleon Currents

T. Minamisono, K. Matsuta, Y. Nojiri, and K. Takeyama

Department of Physics, Faculty of Science, Osaka University
Toyonaka, Osaka 560, Japan

Experimental evidence for the non existence of the G-parity violating second class current (SCC) in weak nucleon currents has been given by us[1] in 1977 and later also by others[2]. Namely, the form factor f_T of the induced tensor term was small[3] compared with the weak magnetism term f_W, viz. $f_T/f_W = -(0.02\pm0.17)$ was obtained from the measurement of the alignment-correlation coefficients of nuclear spin aligned ^{12}B and ^{12}N. However, in order to see to what extent the foundation of the gauge theory and current algebra is experimentally guaranteed, we need to place more strict limitation on SCC. For this purpose, remeasurements of the alignment-correlation terms of mass number 12 system as a function of β-ray energy were performed by use of new experimental equipments and methods of measurement. Namely, a reaction chamber made of plastics and an air-core magnet, by which β-ray scattering was largely reduced, were used to measure distortion free β-ray energy spectra with gain-stabilized plastic-counter telescopes. Also, experimentally studied was the response function of β-ray counter telescopes to the monochromatic β rays as well as the linearity of the pulse height as a function of β-ray energy. The way of the production of the spin aligned ^{12}B and ^{12}N nuclei was essentially the same with that of the previous works[1]. Positive and negative alignments of $A = \pm0.15$ and ±0.25 respectively for ^{12}B and ^{12}N with negligibly small residual polarization of about $P \cong 0.001$ were artificially produced from the nuclear polarizations obtained in nuclear reactions, $^{11}B(d,p)^{12}B$ and $^{10}B(^3He,n)^{12}N$, respectively. For the conversion of the polarization into the alignment, NMR technique was employed for those nuclei implanted in Mg crystal in which the nuclear quadrupole interaction was effective and this was superposed to the main magnetic interaction with external field to cause uneven energy separation in the magnetic substates. And the selective rf transitions (NMR) were possible for the spin handling.

The β-ray angular distribution functions from oriented ^{12}B and ^{12}N have been given by Morita et al.[3] among others as,

$$W(E,\theta) \propto pE(E-E_0)^2B_0(E)[1 + P\frac{B_1(E)}{B_0(E)}P_1(\cos\theta) + A\frac{B_2(E)}{B_0(E)}P_2(\cos\theta)].$$

B_2/B_0 is the alignment correlation term, which is given by $\alpha_{\mp}E + O(E^2)$, where $O(E^2)$ is the higher order term which is dependent on the square of the β-ray energy. Koshigiri et al.[4] showed that the difference of B_2/B_0 values of ^{12}B (β^- emitter) and ^{12}N (β^+ emitter) divided by β-ray energy, $[(B_2/B_0)_- - (B_2/B_0)_+]/E \equiv \Delta\alpha$ is constant for $E > 5$ MeV. Therefore, the extraction of $\Delta\alpha$ from the experimental data is simple and easy. The difference $\Delta\alpha$ contains[3-5] the SCC term as, $f_T/f_A = -0.75[(B_2/B_0)_- - (B_2/B_0)_+]/E + a$, where f_A is the axial vector coupling constant and "a" is the weak magnetism term.

Present experimental results of B_2/B_0 as a function of β-ray energy are shown in Fig. 1 together with the theoretical prediction given by Koshigiri et al[4]. in which the impulse approximation with $f_T = 0$ was employed. Also, the core polarization and meson exchange effects were taken into account in the prediction of the time component. It is clear that each experimental B_2/B_0 value of ^{12}B and ^{12}N agrees with the theoretical value, respectively. However, it is pointed out that the experimental value of ^{12}N is lower than the theoretical value by about 20 %.

The difference of the experimental (B_2/B_0) values shown in Fig. 2 clearly shows its linear dependence on E, while the sum shows a small quadratic dependence. The difference, $\Delta\alpha = [(B_2/B_0)_- - (B_2/B_0)_+]/E = +(0.284\pm0.011)$ %/MeV is obtained. Provided that the strong CVC is valid, the magnitude of the induced tensor f_T is extracted by comparing this $\Delta\alpha$ with the weak magnetism term experimentally determined. One "a" factor is obtained from the spectral shape factors of the mass 12 system determined by Wu et al. and Kaina et al.[6], i.e. a = +(0.199±0.016) %/MeV, and we obtain f_T/f_W = -(0.09±0.12). The other "a" factor is obtained from the radiative decay width of 15.11 MeV state of ^{12}C to the ground state, Γ_γ= 37.0±1.1 eV[7], i.e. a = +(0.2118±0.0030)%/MeV, and we obtain f_T/f_A = -(0.024±0.165)/2M and f_T/f_W(CVC) = -(0.008±0.056). Both f_T/f_W values are in good agreement with each other, and are consistent with the previous results[1]. Present results strongly prove the non existence of SCC within 6% level of the weak magnetism term; strict limitation on SCC is obtained.

Assuming f_T=0, we find that the experimental $\Delta\alpha$ is ~13 % larger than the theoretical one[4] based on the impulse approximation with the core polarization and meson exchange effects included in the prediction of the time component. This may indicate meson exchange and core polarization effects in the nuclear matrix elements[8], and/or the renormalization of the axial vector coupling constant of about this amount.

From the average of the sum of B_2/B_0 values shown by closed circles, the time component b_y is singled out and the value b_y = 3.9/2M shows a large discrepancy from the prediction, b_y = 3.1/2M which is deduced following the same averaging method for the theoretical value shown in Fig. 1 as that used for the experimental one. This may indicate that the exchange current effect is larger than 30 % and/or the core polarization effect is less than 30 % in the time component[4].

This work was supported in part by Yamada Science Foundation and the Grant in Aid for Scientific Research.

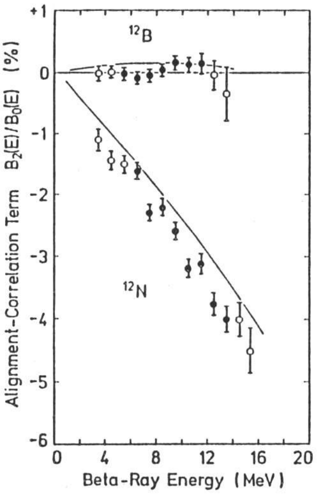

Fig. 1. Alignment-correlation terms for ^{12}B and ^{12}N. Solid lines are theoretical ones[4].

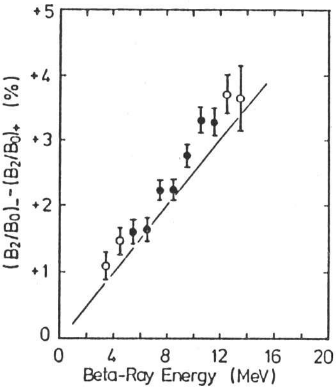

Fig. 2. Difference of B_2/B_0 for ^{12}B and ^{12}N. Closed circles are data used for the analysis. Solid line is theoretical one[4].

References

1) K. Sugimoto, T. Minamisono, Y. Nojiri and Y. Masuda: Invited talk and a contribution to Int. Conf. Nucl. Struct., Sep. 5-10, 1977, Tokyo, Japan: J. Phys. Soc. Japan 44 (1978) 801: Phys. Rev. Lett. 43 (1979) 1083.
2) H. Brändle et al.: Phys. Rev. Lett. 41 (1978) 299.
3) M. Morita et al.: Prog. Theor. Phys. Suppl. 60 (1976) 1: Phys. Lett. 73B (1978) 17: and references therein.
4) K. Koshigiri, H. Ohtsubo and M. Morita: Prog. Theor. Phys. 66 (1981) 358: Private Communication.
5) K. Kubodera, H. Ohtsubo and Y. Horikawa: Phys. Lett. 58B (1975) 402.
6) C. S. Wu et al.: Phys. Rev. Lett. 39 (1977) 72: Phys. Rev. Lett. 10 (19963) 253: W. Kaina et al.: Phys. lett. 70B (1977) 411.
7) B. T. Chertok et al.: Phys. Rev. C8 (1973) 23.
8) K. Koshigiri, H. Ohtsubo and M. Morita: this symposium.