Proc. Sixth Int. Symp. Polar. Phenom. in Nucl. Phys., Osaka, 1985
J. Phys. Soc. Jpn. 55 (1986) Suppl. p. 1014-1015

6.14 # Beta-Ray Angular Distributions from Aligned ^{12}B and ^{12}N and Induced Tensor Current

K. Koshigiri, H. Ohtsubo*, and M. Morita*

Department of Physics, Osaka Kyoiku University, Osaka 543, Japan
*Department of Physics, Osaka University, Toyonaka, Osaka 560, Japan

In the seventies the beta-ray angular distributions from aligned ^{12}B and ^{12}N were repeatedly measured and theoretically studied to clarify possible existence of the second-class induced tensor term in weak charged nucleon currents. Based on the experimental data given by the Osaka, Louvain, and Zürich groups, we made a conclusion that the induced tensor form factor is vanishingly small, such as $f_T/f_A = -(0.059 \pm 0.486)/2M$[1]. Since, however, uncertainties in the experimental results were still large, a continual effort has been done by the Osaka group to reduce these uncertainties in the last six years, and their refined experimental data are reported in this symposium, where the error bars are reduced by about four times[2]. In this connection, we would like to report also a careful investigation on the same subject, which has been performed by the theory group in Osaka.

Generally, the beta-ray angular distributions can be expressed by

$$W(\theta) \propto B_0(E) + PB_1(E)P_1(\cos\theta) + AB_2(E)P_2(\cos\theta), \qquad (1)$$

where the coefficients $B_n(E)$'s have complicated energy dependences. In this abstract we follow the notation in Ref. 3). After numerical calculations, we can practically express the above formula in the following form:

$$W(\theta) \propto 1 + P(p/E)(1 + \alpha_{\mp}E)P_1(\cos\theta) + A\alpha_{\mp}EP_2(\cos\theta) \quad \text{for } \beta^{\mp}, \qquad (2)$$

with

$$\alpha_{\mp} = (1/3)[\mp(f_V\int\vec{\alpha} \times \vec{r}/f_A\int\vec{\sigma}) \mp 2(f_T/f_A) - (y/M)], \qquad (3)$$

$$\int\vec{\alpha} \times \vec{r} = (4.706\int\vec{\sigma} + \int\vec{\ell})/M \quad \text{and} \quad y = -2Mi\int\gamma_5\vec{r}/\int\vec{\sigma}. \qquad (4)$$

Since we have new experimental values of α_- and α_+, we are able to find a new limit of f_T/f_A by using the experimental data on the difference[2],

$$(\alpha_- - \alpha_+)_{exp} = 0.2841 \pm 0.0111. \qquad (5)$$

This can be done if we know the weak magnetism $\int\vec{\alpha} \times \vec{r}$ and the Gamow-Teller matrix $\int\vec{\sigma}$, as is seen in eq. (3).

First, we derive these two matrices by using experimental informations only. In fact, the M1 decay width, $\Gamma_\gamma = (37.0 \pm 1.1)$ eV, of the 15.11 MeV state in ^{12}C gives us

$$(4.706\int\vec{\sigma} + \int\vec{\ell})_{exp} = 4.855 \pm 0.072. \qquad (6)$$

A possible isospin mixing of the T = 0 component can be evaluated from the data on the electron scattering by exciting the 12.71 MeV state in ^{12}C. An admixture of about 6 % is expected, and it is taken into account in the above numerical value. The Gamow-Teller matrices $\int\vec{\sigma}$ are derived from the ft values for the mirror beta decays, $ft_- = (11,710 \pm 40)$ s and $ft_+ = (13,040 \pm 80)$ s. Higher order corrections to the allowed beta decay are properly taken into consideration. If we adopt an average of $\int\vec{\sigma}_-$ and $\int\vec{\sigma}_+$ for the mirror decays, we have

$$[(f_A/f_V)\int\vec{\sigma}]_{exp} = -(1.212 \pm 0.006). \qquad (7)$$

The ratio of eqs. (6) and (7) is

$$(f_V\int\vec{\alpha} \times \vec{r}/f_A\int\vec{\sigma})_{exp} = -(4.01 \pm 0.06)/M. \qquad (8)$$

Using eq. (3) and the experimental values (5) and (8), we have

$$(f_T/f_A)_{exp} = -(0.08 \pm 0.20)/2M \quad \text{or} \quad (f_T/f_W)_{exp} = -0.03 \pm 0.07. \qquad (9)$$

In our previous work[3] we have studied exchange-current and core-polarization effects only for the time component y of the axial vector current. Here we show our investigation with exchange-current effect for the space components, $f_V\int\vec{\alpha} \times \vec{r}$ and $f_A\int\vec{\sigma}$, of both vector and axial vector currents. In the following, we adopt a general 0p-shell model of Hauge and Maripuu[4]. We first calculate $\int\vec{\sigma}$ and $\int\vec{\alpha} \times \vec{r}$ in the impulse approximation, while the exchange currents enhance the space component of the vector current by about 2.7 % and reduce that of the axial vector current by about 5.1 %[5].

$$4.706\int\vec{\sigma} + \int\vec{\ell} = 4.934 \times (1 + 0.027) = 5.067 \qquad (10)$$

and

$$(f_A/f_V)\int\vec{\sigma} = -1.260 \times 1.0586 \times (1 - 0.051) = -1.266. \qquad (11)$$

Hence we have

$$f_V\int\vec{\alpha} \times \vec{r}/f_A\int\vec{\sigma} = -4.00/M. \qquad (12)$$

Equations (3) and (12) together with the new experimental data (5) bring us the limits of f_T as

$$f_T/f_A = -(0.08 \pm 0.15)/2M \quad \text{or} \quad f_T/f_W = -(0.03 \pm 0.05). \qquad (13)$$

Possible nuclear structure effects other than we considered here to individual matrix elements may be small, as is seen by comparing eqs. (6) and (10) and also eqs. (7) and (11). Furthermore, such effects are cancelled in the ratio, as is seen in a remarkably good agreement between eqs. (8) and (12). We also notice here that the beta-ray spectra of ^{12}B and ^{12}N can be beautifully explained with the ratio of the weak magnetism and the Gamow-Teller matrix in eq. (12). The second-class induced tensor current is once again proved for its vanishingly smallness. A study on the time component y of the axial vector current is still being performed.

References

1) For a summary, see e. g., M. Morita: Hyperfine Int. 21 (1985) 143.
2) T. Minamisono, K. Matsuta, Y. Nojiri and K. Takeyama: this symposium.
3) M. Morita, M. Nishimura, H. Ohtsubo and J. Yamane: J. Phys. Soc. Japan Suppl. 44 (1978) 407. K. Koshigiri, H. Ohtsubo and M. Morita: Prog. Theor. Phys. 66 (1981) 358.
4) P. S. Hauge and S. Maripuu: Phys. Rev. C8 (1973) 1609.
5) M. Fukui, K. Koshigiri, T. Sato, H. Ohtsubo and M. Morita: Prog. Theor. Phys. 70 (1983) 827.