Alignment correlation term in β-ray angular distribution from spin aligned ^{13}B

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The alignment correlation term in β-ray angular distribution is one of the sensitive probes to test the G-parity conservation law in weak nucleon currents (V_μ, and A_μ), including 4 extra terms induced by the strong interaction.

$$V_\mu = i\overline{\psi}_p(f_V\gamma_\mu + f_W\sigma_{\mu\nu}\kappa^\nu + if_S\kappa_\mu)\psi_n \tag{1}$$

$$A_\mu = i\overline{\psi}_p\gamma_5(f_A\gamma_\mu + f_T\sigma_{\mu\nu}\kappa^\nu + if_P\kappa_\mu)\psi_n \tag{2}$$

Among these 4 induced terms, only the induced scalar f_S and the induced tensor f_T terms are G-parity violating terms. The alignment correlation term includes both of the weak magnetism term f_W and the G-parity violating induced tensor term f_T. In the present research, such alignment term has been observed for β rays from aligned ^{13}B, precisely, in order to investigate f_T. The $\beta^\mp$-ray angular distribution from purely aligned unstable nuclei is described as,

$$W(\theta) \propto 1 + \left(\frac{B_2(E)}{B_0(E)}\right)_\mp \mathcal{A}\left(\frac{3cos^2\theta - 1}{2}\right) \tag{3}$$

Here, θ, E and A are the emission angle, the total energy of $\beta^\mp$ particles and the nuclear alignment, respectively. Hear, the alignment correlation terms $\{B_2(E)/B_0(E)\}_\mp$ are for the mirror $\beta^\mp$ decay of ^{13}B and ^{13}O, respectively.

The experimental procedure is similar to the previous experiment [1]. The ^{13}B nuclei were produced through the projectile fragmentation process in heavy ion collisions, bombarding 1-mm thick Be target with an enriched ^{15}N beam at 64 A MeV. The ^{13}B nuclei were separated from other reaction products, by a fragment separator installed in the EN course of RCNP. By selecting reaction angle of $(2.0 \pm 1.2)^\circ$ and fragment momentum $\Delta p/p$ = (2 ± 1)%, nuclear spin polarization as large as 11 % was obtained in ^{13}B nuclei. The ^{13}B nuclei were then slowed down by an energy degrader and stopped in a 0.5-mm thick TiO_2 single crystal placed under the strong magnetic field of 2.024 kOe to maintain the polarization. The crystalline c-axis was set parallel to the external field. Beta rays emitted from the stopped ^{13}B and come through the hole of the magnet pole, were detected by two sets of counter telescopes. Typical β-ray counts were 140 cps for the primary ^{15}N beam of 50 particle-nA. In the time spectrum, no contamination was seen and ^{13}B beam was shown to be pure.

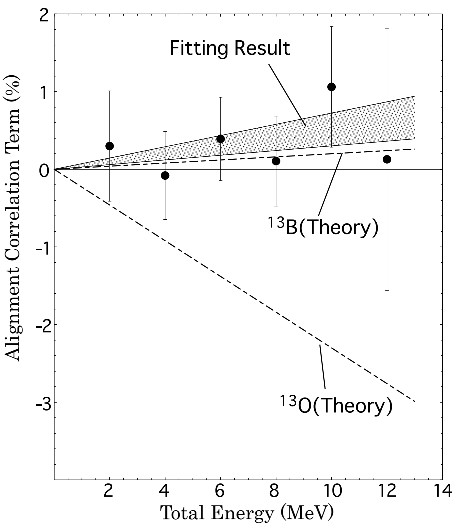

Figure 1: Alignment correlation term for ^{13}B. Theoretical values are also shown.

Series of rf oscillating magnetic fields were applied in a certain sequence by an rf coil installed around the catcher crystal, to induce NMR/NQR for converting reaction polarization to the spin alignments of both signs. The nuclear polarization for each time step was monitored by the asymmetry in the β-ray counts, as a function of time. Positive and negative alignments were obtained at the time sections in the same beam cycle.

Comparing energy spectra for positive and negative alignments, the alignment correlation term B_2/B_0 was deduced, as is shown in Fig. 1, together with the theoretical prediction values for both ^{13}B and ^{13}O. When we assume linear dependence, the B_2/B_0 is expressed as αE, where α is the alignment correlation coefficient. From the linear fitting analysis, the coefficient is obtained as, $\alpha_- = +(0.05 \pm 0.02)\%$ /MeV. Comparing with the theoretical coefficient for ^{13}B ($\alpha_- = +0.02$ %/MeV), a preliminary result for the induced tensor term is obtained as $2Mf_T/f_A$ = - (0.8 ± 0.5), assuming theoretical weak magnetism and axial charge matrices. This deviation from zero f_T value should not be taken so serious. For the more precise value, we are going to add more counting statistics.

References

[1] K. Minamisono *et al.* Phys. Rev. C **65**, 015501-1-17(2002).