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7.6 Measurement of the Energy Dependent Beta Asymmetry in the Decay of ^{8}Li

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Measurements of various correlations in allowed beta decay permit one to determine weak magnetism, induced and second forbidden form factors[1]. Experiments have been carried out for several systems. For A=8 the beta-alpha correlations[2] for ^{8}Li and ^{8}B decay and the beta decay asymmetry[3] of ^{8}Li have been measured. The data are consistent with the conserved vector current hypothesis and the absence of second-class-currents, but the beta-alpha correlation measurement does not reproduce theoretical estimates of recoil order axial vector matrix elements. The asymmetry measurement agrees with CVC only when ad-hoc corrections are applied to the low energy portion of the beta spectrum. We report here our progress on a new measurement of the beta decay asymmetry in ^{8}Li.

The β-decay angular distribution from a polarized nucleus is given by

$$W(E,\theta) = 1 + (\frac{v}{c})\ PA(E)\ \cos\theta, \tag{1}$$

where E is the outgoing beta energy, and θ is the angle between the beta and the polarization symmetry axis, and P is the nuclear polarization. The asymmetry parameter A(E) may be expressed as a constant plus a small energy dependent part via

$$A(E) = A_0(1 + \alpha(E)). \tag{2}$$

Here, A_0 is given in the allowed approximation and $\alpha(E)$ amounts to a few percent variation. The term $\alpha(E)$ contains information on recoil order effects[1]. We extract A(E) by measuring the yields at 0° and 180° from the polarization direction:

$$\Delta(E) = \frac{W(E,0°) - W(E,180°)}{W(E,0°) + W(E,180°)} \tag{3}$$

and

$$(\frac{v}{c})\ \alpha(E) = \frac{\Delta(E)}{\langle\Delta(E)\rangle} - 1. \tag{4}$$

In equation 4, $\langle\Delta(E)\rangle$ is averaged over beta energy and hence approximates PA_0. In practice, we change the angle by reversing the polarization direction.

Polarized ^{8}Li is produced via the reaction $^7\mathrm{Li}(\vec{d},p)^8\mathrm{Li}$ using vector polarized deuterons from the University of Wisconsin crossed-beam polarized source. The target is enriched ^{7}Li metal ≈ 1mm thick, sufficient to stop most of the recoil ^{8}Li nuclei. The target is operated near liquid nitrogen temperature in a holding field of 3mT. The depolarization time is longer than the beta decay lifetime (840ms). In the actual experiment, three independent sets of electron detector systems are used, at 0°, 180° and 90° to the polarization axis. The detector at 90° is used for measurements of the tensor polarization correlation, and to monitor the target activity. The detectors each consist of two thin (1mm plastic scintillator) coincidence counters, one large (10cm thick) energy measuring detector, and a thin anticoincidence counter in front of the total energy detector to help define the solid angle. A low energy beam (1.8 MeV) is chosen to avoid background from contaminating reactions. A beam current of approximately 2nA provides the desired target activity. The beam is pulsed on for a one-second period followed by a counting period of three seconds, after which the polarization is reversed and the cycle is repeated. We find Δ ≈ 5%, and since A_0 = 1/3, P ≈ 15%. Peak count rates (with beam off) are 1kHz coincidence per detector system.

Our results are shown in Fig. 1. The energy scale is estimated by a fit of an allowed beta spctrum, convoluted by the expected detector response function, to an unpolarized ^{8}Li beta spectrum. The solid curve is the result expected using the wave functions of Boyarkina to calculate the recoil order axial vector matrix elements[2]. Recoil order vector matrix elements are derived from the results in Ref.[4]. The data agrees, although better statistics are needed. The fall-off at low energies due to the v/c factor is evident. We are presently aiming at reducing the statistical error by a factor of 3.

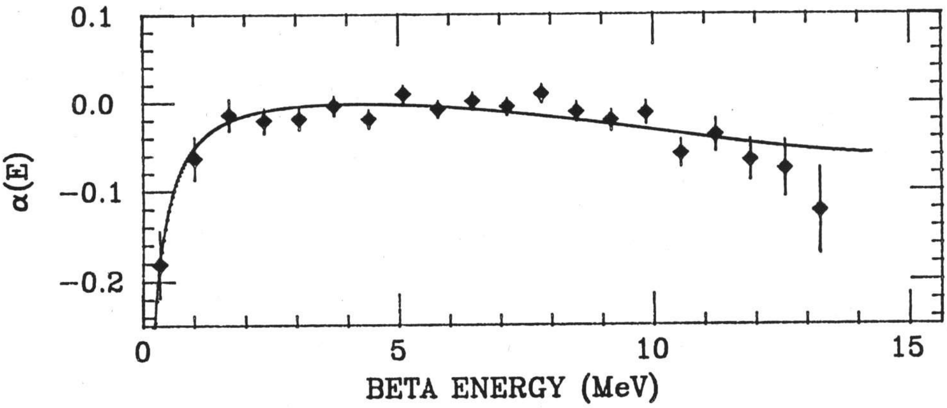

Fig. 1. The energy dependent part of the beta asymmetry vs. beta energy.

There are several possible sources of systematic error. These include gain shifts, over time as well as a function of count rate, corrections due to pile-up of random total energy signals, presence of tensor polarization and attendant correlations, different degrees of polarization and total current depending on the polarization direction, and a variety of other smaller effects. We have shown that these effects are negligible at the present level of statistics. However, systematic effects must be well understood at the intended level of statistical precision.

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