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7.7 Beta Decay of Polarized Nucleus ^{15}C Produced in Heavy-Ion Reaction

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Studies of β-decay of oriented nucleus have been valuable sources of information on fundamental interactions and nuclear structures. The testing ground for such investigations however has been limited to nuclei near the valley of stability. Recent progresses in accelerator and instrumentation have opened a new possibility of access to region more removed from stability line. Substantial sizes of polarization observed[1] for projectile-like fragments in heavy-ion reactions suggest a useful application of these reaction products to β-decay studies.

We report on the study of β-decay of the neutron-rich nucleus ^{15}C ($T_{1/2}$ = 2.449 s, Q_β = 9.772 MeV) to the ground state of ^{15}N. This $1/2^+ \rightarrow 1/2^-$ non-unique first-forbidden transition receives contributions from the rank-zero and rank-one matrix elements,[2] and is interesting in the study of many-nucleon system involving virtual mesons, since the rank-zero matrix element is dominated by the time-like component A_0 of the weak axial-vector current in which the mesonic exchange effect is predicted to enhance.[3] Extraction of the rank-zero contribution from the total transition probability requires an experimental discrimination between the rank-zero and rank-one contributions. This can be done by observing asymmetry[4] in the angular

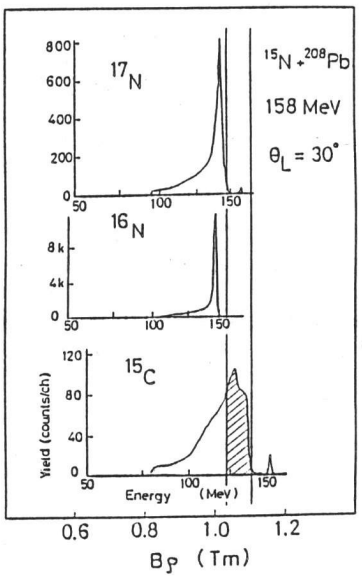

Fig. 1. Schematic illustration of isotope separation using DUMAS, according to the magnetic rigidity Bρ. Bρ spectra are shown for the β-emitting products with half-lives ranging from 0.1 to 100 s.

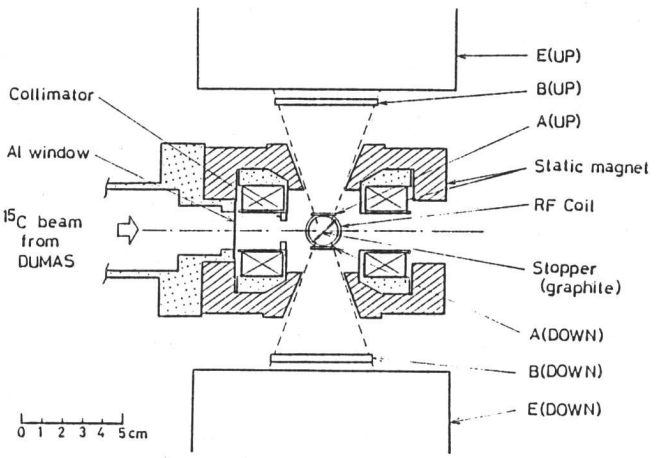

Fig. 2. Experimental setup used in the measurement of β-ray asymmetry.

distribution of β-rays from polarized nuclei.

The present work thus aims at measurement of β-ray asymmetry for ^{15}C. In addition the asymmetry is utilized to detect the NMR for determination of the magnetic moment of ^{15}C which provides additional information on wave function of the parent state. 160 MeV ^{15}N beam from the AVF cyclotron at the Research Center for Nuclear Physics, Osaka University is used. The spectrometer DUMAS[5] provided a means for isotope of separation of projectile-like fragments produced in the heavy-ion reaction as illustrated in Fig. 1, where the Bρ-distribution of ^{15}C deduced from the observed energy spectrum is presented together with those of the typical interfering β-emitters ^{16}N and ^{17}N.

Reaction products emitted from the target at $\theta_L = 25°$ were transmitted to DUMAS, in which those with Bρ = 0.99 - 1.07 Tm passed through the momentum slit in the medium focal plane and then were triple-focussed on a stopper (high-purity graphite) placed at the second focal point. Setup used for the measurement of β-ray asymmetry is schematically shown in Fig. 2. β-rays emitted from the products implanted in the stopper were detected by using counter telescopes located above and below the stopper. Observed time and energy spectra of β-rays revealed that the background contribution due to activities other than ^{15}C is indeed small. Spin inversion technique by means of NMR was utilized in the asymmetry measurement: Up/down ratio of β-ray yield was measured both with spins inverted by applying rf field for NMR, and with spins unaltered. The result for the β-transition to $^{15}N(1/2^+)$ (Gamow-Teller) is shown in Fig. 3, from which ^{15}C spin polarization was deduced to be + 3.3 ± 1.6 %.

The results obtained so far show that the polarized ^{15}C nuclei are available for experiment in the reactions used here and that the value of magnetic moment of ^{15}C lies in the region between 1.0 and 2.0 n.m. Development of setup for the final measurement on β-ray asymmetry and magnetic moment is now in progress.

References

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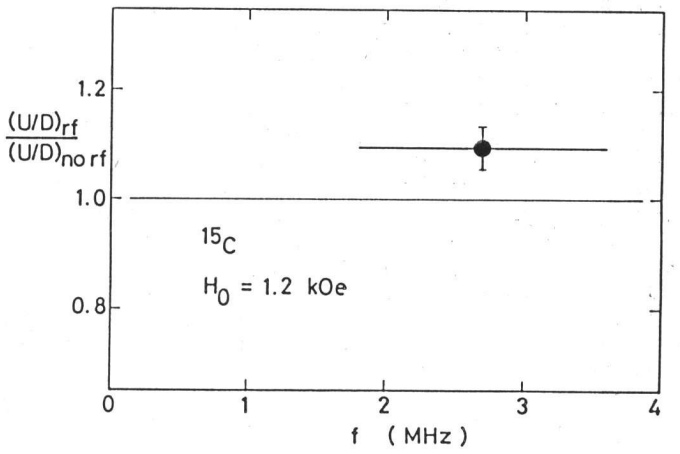

Fig. 3. Up/down ratio of β-ray yield with the rf field on, normalized to that without application of the rf field. Horizontal bar represents the range of frequency over which the rf was swept.