Measurement of nuclear magnetic moment of neutron-rich ^{39}S

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Ground-state nuclear electromagnetic moments of unstable nuclei have been measured with the β-ray detected nuclear magnetic resonance (β-NMR) method [1] using fragmentation-induced spin-polarized radioactive isotope (RI) beams[2]. In this method, a resonance can be observed when all three conditions are met at the same time: 1) a polarized RI beam is produced; 2) the frequency range of the oscillating magnetic field in β-NMR measurements covers a resonance frequency; and 3) polarization is maintained in the stopper material during count time. These conditions complicate β-NMR measurements. In order to investigate the production of spin polarization separately from the resonance scan, a new adiabatic field rotation (AFR) system has been developed.[3,4]

The experiment was carried out at the RIKEN Projectile Fragment Separator (RIPS) at the RI Beam Factory operated by RIKEN Nishina Center in September 2015. Nuclear spin-polarized ^{39}S nuclei were produced by bombarding ^{48}Ca ions on a 0.52-mm-thick ^{9}Be target for the first time. The $^{48}Ca^{17+}$ ions were accelerated up to 63 MeV/nucleon and the intensity of the primary beam was typically ~200 pnA on the target. The fragments emitted into the angle from 1.5° to 5.9° relative to the primary beam with the momentum $p = p_0 \times (1.02 \pm 0.02)$, where p_0 is the peak in the distribution, were selected by the RIPS. A wedge-shaped degrader (148.8 mg/cm^2) was used for energy loss separation, and then, the ^{39}S ions were transported to the AFR and β-NMR apparatus. Next, they were implanted into a CaS crystal together with inseparable fragments as contaminants that became low energy β-ray emitters. Under these conditions, the beam purity of ^{39}S was about 70%.

First, AFR measurements were conducted with ^{39}S nuclei. The experimental setup of the AFR measurement is described in Ref. 5). The maximum asymmetry change (AP) is normalized to be a product of the asymmetry parameter A and polarization P. The AP values for AFR measurements of ^{39}S in CaS are shown in Fig. 1, where the plot points 1-5 correspond to the conditions shown in Table 1. Table 1 shows the time sequence of beam on/off period, selected momentum, selected angle, and obtained yield of β-ray from ^{39}S (Y_β). As per the results of AFR measurements, we were successfully in achieving nuclear spin-polarization.

Second, β-NMR measurements by means of the adiabatic fast passage (AFP) method were carried out with ^{39}S nuclei. The experimental setup of the AFP-NMR measurement is the same as described in Ref. 6). Because the range of theoretically predicted g-factor is very wide, a fast switching system was used.[7] In this measurement, the g-factor search was performed in the region $0.14 < g < 1.49$. The results of the AFP-NMR measurements are under analysis.

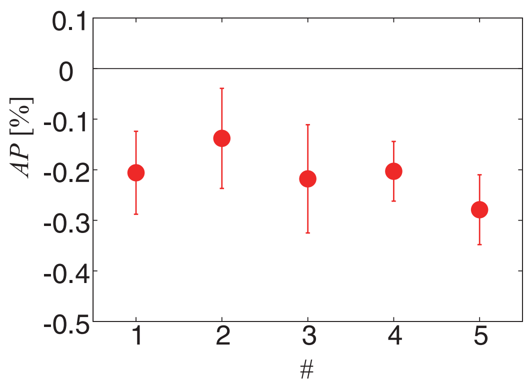

Fig. 1. Obtained AP value of ^{39}S at room temperature.

Table 1. Measurement conditions and obtained Y_β

#	Time sequence	Momentum [%]	Angle	Y_β [cps]
1	2 s - 30 s	$1 \leq \Delta p/p_0 \leq 4$	$\theta \geq 1.5°$	140
2	2 s - 30 s	$1 \leq \Delta p/p_0 \leq 4$	$\theta \geq 1.0°$	150
3	8 s - 24 s	$1 \leq \Delta p/p_0 \leq 4$	$\theta \geq 1.5°$	240
4	16 s - 16 s	$1 \leq \Delta p/p_0 \leq 4$	$\theta \geq 1.5°$	310
5	16 s - 16 s	$0 \leq \Delta p/p_0 \leq 4$	$\theta \geq 1.5°$	420

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