β-NQR measurement of the ^{23}Ne ground state

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In this report, we present some results of the experimental program NP1612-RRC47. The aim of this experiment is to search for an appropriate single crystal for the β-NMR measurement of Ne isotopes and to measure its electric field gradient at the sitting site of Ne, as the first step to the nuclear electromagnetic moment measurement of neutron-rich Ne isotopes. In the present study, we applied the β-NQR method[1)] to the spin-polarized ^{23}Ne, the ground-state Q moment of which has been well-studied,[2)] implanted into the ZnO single crystal.

The experiment was conducted using the RIKEN projectile fragment separator (RIPS). A radioactive ^{23}Ne beam was obtained from the single-neutron pickup reaction of ^{22}Ne at 70 MeV/nucleon on a 0.25-mm thick Be target. In order to produce spin polarization, the primary beam was injected with a tilt angle of 2° with respect to the spectrometer entrance (F0), where the Be target was located. Fragments were accepted at a finite angle $\theta = 1°–3°$ to the primary beam direction, and the center of the momentum distribution ($\Delta p/p \leq | \pm 0.25\%|$) was selected at momentum dispersive focal plane F1. A secondary beam of ^{23}Ne with a purity higher than 90% was separated with a 321-mg/cm^2 thick Al wedge degrader. The intensity of the spin-polarized ^{23}Ne was 5×10^4 pps with a ^{22}Ne beam intensity of 400 pnA.

The spin-polarized ^{23}Ne was implanted in a ZnO single crystal (28 mm × 20 mm × 0.5 mm, inclined at 45° to the horizontal plane), which was located at the center of the β-NMR apparatus. The c-axis of the ZnO single crystal was along the vertical axis. A static magnetic field of 0.5 T was applied to the crystal parallel to its c-axis, and an oscillating magnetic field was applied by a pair of RF coils perpendicular to the static magnetic field. The crystal was cooled to $T \sim$ 50 K to achieve a longer spin-lattice relaxation time than the ^{23}Ne β-decay half-life ($T_{1/2} = 37$ s).

The β rays from the β decay of ^{23}Ne was detected through a vacuum chamber wall, made of 1-mm thick fiber-reinforced plastic, by two β-ray telescopes which were located above and below the crystal. Each telescope consists of a stack of three 1.0-mm thick plastic scintillators. The telescopes cover approximately 50% of the entire solid angle.

In the experiment, we first measured the g-factor of the ^{23}Ne ground state with a NaF polycrystalline stopper by the β-NMR method to confirm the polarization of the ^{23}Ne beam. In this measurement, we observed a nuclear magnetic resonance at 1653.8(5) kHz; thus, a g-factor of $g = 0.43305(14)$ was deduced. The obtained g-factor is consistent with the literature values $g =$ 0.432(4)[3)] and 0.43268(36).[4)] The polarization of the ^{23}Ne beam was also determined to be $AP = 5.0(4)\%$.

After measuring the g-factor, we performed the β-NQR measurement of ^{23}Ne by using the ZnO single crystal. Figure 1 shows the obtained β-NQR spectrum of ^{23}Ne in the ZnO single crystal. In the figure, a clear β-ray asymmetry change is found at $\nu_Q(= eqQ/h) =$ $1.08(5)\times10^3$ kHz. From the obtained ν_{Q} and the Q moment [Q = 145(13) emb],[2)] the electric field gradient q was determined to be $|q| = 31(3)\times10^{19}$ [V/m^2]. Now, we are ready to measure the ground-state electromagnetic moments of neutron-rich Ne isotopes.

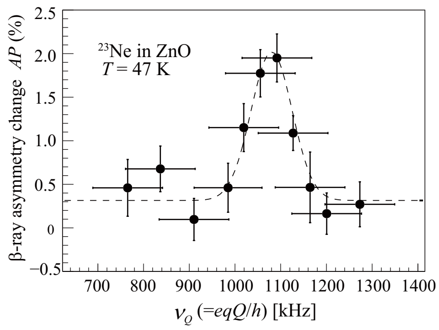

Fig. 1. Beta-NQR spectrum of ^{23}Ne implanted into the ZnO single crystal. The dashed line shows the least chi-square fitting result with a Gaussian function plus a constant. The horizontal error bars indicate the width of the swept frequency ($\Delta\nu_{\mathrm{Q}} = 1.5 \times 10^2$ kHz).

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