β-NMR measurements of ^{21}O

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Oxygen nuclear magnetic resonance (NMR) serves as a powerful tool to realize the atomic-scale properties of a vast variety of oxygen-containing materials. Such studies, however, have been so far complicated by different objective limitations such as low natural abundance of the NMR-active ^{17}O isotope, and difficulties and costliness of the isotopic enrichment. Alternatively, the ^{13}O and ^{19}O isotopes with known values of nuclear moments would seem appropriate to be used in β-ray-detected nuclear magnetic resonance (β-NMR) studies. However, the use of these isotopes also has strong disadvantages such as low beam purity in case of proton-rich ^{13}O and relatively long lifetime of ^{19}O($T_{1/2}$ = 26.5 s) leading to the insufficient NMR-signal intensity. All these aspects make ^{21}O a good candidate to be used as a probe to investigate the structure and properties of oxide-based systems. As a first step for such studies, the electromagnetic moments of this isotope must be determined.

In the present research, we measured the ground-state magnetic dipole moment and electric quadrupole moment of the ^{21}O isotope. The experiment was carried out using the projectile-fragment separator RIPS at the RIBF facility. A secondary beam of ^{21}O was produced in the projectile fragmentation reaction involving one neutron pick-up reaction of a ^{22}Ne beam at 69A MeV on a 1.0-mm-thick Be target. The two-stage isotope separation through the momentum and momentum-loss analyses by RIPS was applied to purify the ^{21}O beam. The momentum window and emission angle of the primary beam were selected to be $p_F = p_0 \times (0.97 \pm 0.03)$ and $\theta_F > 2.1°$, respectively.

Electromagnetic moments were measured by means of the β-NMR/NQR method in combination with the adiabatic fast passage (AFP) technique[1]. In the g-factor measurements the beam was implanted into the 0.5-mm-thick CaO stopper placed at the center of the dipole magnet of the β-NMR system that provided a static magnetic field of ∼500 mT. Some of the obtained NMR spectra are presented in Fig. 1. The NQR measurements, in turn, require the presence of the electric field gradient (EFG) in the medium.

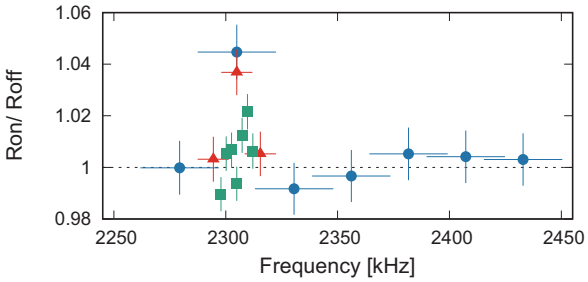

Fig. 1. β-NMR spectra of ^{21}O in a CaO crystal. Frequency sweeps with the widths of 35 kHz, 14 kHz and 3 kHz are plotted with blue circles, red triangles and green squares, respectively. During the experiment the total frequency range from 1956 kHz to 2445 kHz was scanned.

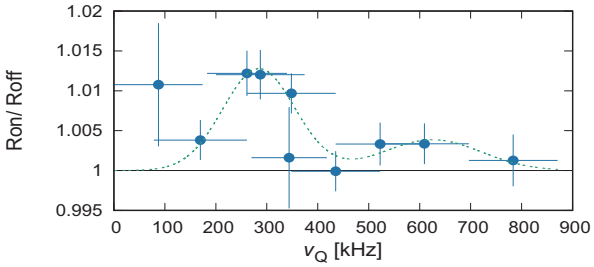

Fig. 2. β-NQR spectrum of ^{21}O in the TiO_2 single crystal. The dashed curve is a guide to the eye representing the expected fitting curve shape. The actual fitting analysis is work-in-progress. For the definition of ν_Q, see Ref. 2.

For this purpose the 0.5-mm-thick TiO_2 single crystal with a known value of EFG was used as a stopper and placed in the same magnetic field of ∼500 mT. The obtained NQR spectrum is shown in Fig. 2. R_{on} and R_{off} in Figs. 1 and 2 represent the U/D ratios between the counts of upper and lower plastic scintillators with and without the application of oscillating magnetic field, respectively.

The analysis of the obtained NMR/NQR spectra is in progress.

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