β-NMR measurements for ^{21}O at HIMAC

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The interest in the shell evolution in the region of neutron-rich oxygen isotopes has its origin in the multiple studies on ^{23}O, which have revealed the anomalous nuclear properties of this isotope. The appearance of the new neutron magic number at $N = 16$ as well as the formation of the halo structure in ^{23}O have been experimentally indicated.[1,2] Thus, the information on the nuclear structure of the neighboring isotopes, such as ^{19,21}O, can provide the systematic picture of the change in the nuclear properties in this region.

In parallel with the interest in the nuclear structure, the ^{21}O isotope has a large potential in materials science studies. Owing to it's advantages in the beta-ray-detected NMR measurements, as compared to other oxygen isotopes with known electromagnetic moments,[3] ^{21}O appeared to be a good candidate to serve as the electromagnetic probe to investigate the atomic-scale properties of the oxygen-containing systems.

Previously, we have reported on the measurement of nuclear moments of ^{21}O at RIKEN RIBF.[3] However, even though the obtained values provide certain information on the nuclear structure, the improvements in the precision of Q-moment measurement are desirable to successfully implement ^{21}O in the studies described above.

Thus, we prepared and performed precision measurements on the nuclear magnetic dipole and electric quadrupole moments for the ground-state of ^{21}O using the β-NMR method at HIMAC, Chiba. The secondary beam of ^{21}O was produced at the SB2 [4] separation line of the facility by using the ^{22}Ne primary beam on the 1-mm-thick Be target at an energy of 70 MeV/nucleon and beam intensity of $7.8 \cdot 10^8$ particles per spill. The isotope separation was done in two stages through the momentum and momentum-loss analyses. The latter was realized using a 3.5-mm-thick Al wedge-shaped energy degrader installed at the F1 focal plane. Beam purity of nearly 100% was achieved for the secondary beam after the separation. To ensure the polarization of ^{21}O, an emission angle of $\theta = 2.6^\circ \pm 1^\circ$ was applied using the beam swinger located upstream of the SB2 beam line and the outgoing momentum window was selected to be $p_\mathrm{f} = p_0 \times (0.984 \pm 0.020)$ considering the one neutron pick-up mechanism involved in the reaction. The particle identification was done using ΔE-ToF. The time of flight (ToF) was measured between the F1 and F3 focal planes of the beam line.

After the isotope separation, the secondary beam of ^{21}O was delivered to the β-NMR apparatus installed downstream the beam line. The well-established method of β-NMR in combination with AFP technique[5] was applied to measure the electromagnetic moments. The following sequence was implemented in the measurements. The stopper crystal placed in a 5000 G static magnetic field B_0 was irradiated by the secondary beam during the first two spills from synchrotron. After the beam implantation, the oscillating magnetic field was applied to the stopper perpendicular to B_0 by using the tank circuit containing five variable remotely controlled vacuum capacitors of 50–2000 pF. The following six spills (9.9 s) were artificially skipped and the β-rays from ^{21}O β-decay were counted by the plastic scintillator telescopes located above and below the stopper. In the next cycle, the beta-rays were counted without the application of the RF field and the ratio between the two measurements was taken to extract the AP value and therefore, the resonant frequency. The 0.5-mm-thick CaO crystal and 0.5 mm-thick TiO_2 single crystal were used in the g-factor and Q-moment measurements, respectively.

The analysis of the data acquired during the experiment is in progress and the results will be reported later.

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References

1) C. Nociforo *et al.*, Phys. Lett. B **605**, 79 (2005).
2) D. Cortina-Gil *et al.*, Phys. Rev. Lett. **93**, 062501 (2004).
3) A. Gladkov *et al.*, RIKEN Accel. Prog. Rep. **50**, 74 (2017).
4) M. Kanazawa *et al.*, Nucl. Phys. A **746**, 393 (2004).
5) D. Nagae *et al.*, Nucl. Instrum. Methods Phys. Res. B **266**, 4612 (2008).