Nuclear moments of neutron-rich aluminum isotopes

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Ground-state magnetic moments of $^{30,\,32}$Al and electric quadrupole moments of $^{31,\,32}$Al have been measured with the β-NMR method using spin-polarized radioactive-isotope beams [1] produced in the projectile-fragmentation reaction. Important issue in this neutron-rich sd-shell region is to understand what causes the manifestation of the "island of inversion" [2]. Microscopic studies of such nuclei close to the "island of inversion", as well as those inside it, would offer a clue to this question. The obtained nuclear moments are good examples for this study.

Experiments were performed using RIKEN projectile-fragment separator RIPS [3]. Beams of $^{30-32}$Al were obtained from the fragmentation of ^{40}Ar projectiles at an energy of $E = 95\ A$ MeV on a ^{93}Nb target. In order to have the spin-polarized aluminum beams, the emission angle and the outgoing momentum were selected. Then, the spin-polarized fragments were introduced into the NMR apparatus located at the final focus, and implanted into a single crystal of α-Al_2O_3. We employed the β-NMR method [4] to determine the μ- and Q-moments, in which NMR is observed through a change in the β-ray asymmetry.

From obtained NMR spectra, we have determined experimental μ moments $|\mu_{\rm exp}[^{30}{\rm Al}]| = 3.010(7)$ $\mu_{\rm N}$ and $|\mu_{\rm exp}[^{32}{\rm Al}]| = 1.959(9)$ $\mu_{\rm N}$ [5]. They agree well with shell model calculations with the USD interaction, although the reduction in the gap energy between the *sd* and *pf* states is predicted for ^{32}Al in a modern large-scale shell model [6]. In the measurement of Q-moments, $Q_{\rm exp}[^{32}{\rm Al}] = 24(3)$ mb has been determined [7]. We found that the obtained value is much smaller than those of ^{27}Al and ^{28}Al, suggesting a spherical shape of ^{32}Al. Also, we have recently carried out the Q-moment measurement of ^{31}Al. The preliminary obtained value $Q_{\rm exp}[^{31}{\rm Al}] = 82(12)$ mb is again smaller than $Q_{\rm exp}[^{27,\,28}{\rm Al}]$

These observations seem to indicate that these aluminum isotopes are located outside the border. It is interesting to note that the observed "normal" properties of ^{32}Al are in contrast to those of ^{31}Mg, for which anomalous nuclear structure has been reported [8], in spite that these two nuclei differ only in their proton number by one.

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