First observation of ^{28}O†

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The doubly-magic candidate nucleus ^{28}O and its neighboring nucleus ^{27}O have been observed by the invariant mass method at SAMURAI, RIBF. Secondary beams of ^{29}F and ^{29}Ne were produced through the projectile fragmentation of a ^{48}Ca primary beam at 345 MeV/nucleon on a 15-mm-thick beryllium target. The beam energies of ^{29}F and ^{29}Ne were 235 and 228 MeV/nucleon with average intensities of 90 and 8000 particles per second, respectively. In addition to the standard SAMURAI setup for detecting heavy ions and neutrons, a liquid hydrogen target system (MINOS[1)]) and neutron detector array (NeuLAND[2)]) were installed to realize high luminosity and enable three- and four-neutron coincidence detection.

A resonance of the ^{28}O ground state was observed at $0.46^{+0.05}_{-0.04}$ MeV in the decay energy spectrum of ^{24}O and the four neutrons. In addition, a resonance of ^{27}O was observed at 1.09 ± 0.04 MeV in the decay energy spectrum of ^{24}O and the three neutrons. The analysis of partial decay energy spectra of subsystems indicated that the unbound nuclei sequentially decayed through the ^{26}O ground state. The measured energies were compared to theoretical results including *ab-initio*-type calculations, including large scale shell model calculations and a newly developed statistical approach based on the coupled-cluster method.

The measured momentum distribution of ^{28}O following one-proton removal from ^{29}F shows better agreement with the distribution for $d_{5/2}$ proton removal calculated using a distorted wave impulse approximation approach than with the distribution for $s_{1/2}$, leading to a $5/2^+$ assignment for the ^{29}F ground state. A spectroscopic factor of $0.48^{+0.05}_{-0.06}$ was obtained from the measured cross section. From the comparison of the spectroscopic factor to shell model calculations, it is concluded that the $N = 20$ shell closure disappears in ^{28}O.

References

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