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Neutron intruder states above N=50 studied by neutron knockout with HiCARI@RIBF

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The recent spectroscopy of ⁷⁸Ni [1] together with indications of shape coexistence just below the N=50 shell closure for ⁷⁹Zn [2] suggests that deformed intruder configurations could play a crucial role in low-energy structure properties in this region and towards the limits of the nuclear chart. Such configurations are predicted to originate from multiparticle-multihole excitations [3] above the N=50 and Z=28 shell gaps pushed down in energy due to neutron-proton correlations which enhance quadrupole collectivity. Quantifying the way collectivity develops nearby ⁷⁸Ni is crucial since it influences binding energies and the drip-line location [4] with consequences on nucleosynthesis calculations relying on these inputs. Because these intruder states involve many-particle excitations more difficult to describe theoretically, their predicted energies vary more drastically between models [1] than for yrast states originating from "normal"configurations on which they tend to agree. Identifying direct signatures of these intruder configurations is thus of prime interest to benchmark microscopic models or to constrain effective interactions.

This topic is the main goal of an experiment performed at the RIBF facility (RIKEN, Japan) in November 2020 to identify and characterize for the first time 2p-1h intruder states in ⁸³Ge and ⁸¹Zn. Neutron hole states in these two N=51 nuclei were populated via neutron knockout reaction from N=52 nuclei ⁸⁴Ge and ⁸²Zn, both having about two neutrons in the $s_{1/2}d_{5/2}$ valence space above N=50. This direct reaction allows in some cases to remove one of the neutrons from the quasi-full $g_{9/2}$ orbital below N=50 to selectively populate the 9/2+ intruder states based on a $\nu(g_{9/2})^{-1}(s_{1/2}d_{5/2})^{+2}$ configuration.
The necessary secondary beam were produced at the RIBF by in-flight fragmentation-fission of ²³⁸U and selected in the BigRIPS spectrometer while the ZeroDegree spectrometer allows the identification of nuclei after the reaction. In order to identify the populated states, gamma-rays from their in-flight decay were measured using the HiCARI (High-resolution Cluster Array at RIBF) Germanium array composed of 6 Miniball triple clusters, 4 Clovers and two Gretina-type tracking detectors.

The analysis being still ongoing, we propose to present mainly preliminary results for ⁸²Ge (known 2_1^+ and 4_1^+ states populated and used as a benchmark) and for ⁸³Ge (main goal of this experiment). A contributed talk or a poster would be accepted.

[1] R. Taniuchi et al., Nature 569, 53 (2019).

[2] X. Yang et al., Physical Review Letters 116 (2016).

[3] K. Heyde and J. L. Wood, Rev. Mod. Phys. 83, 1467–1521 (2011).

[4] J. Erler et al., Nature 486, 509 (2012).

Topic

Experiment

Author: PLAGNOL, Leo

Co-authors: Dr FLAVIGNY, Freddy (LPC); HICARI COLLABORATION

Presenter: PLAGNOL, Leo

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