Contribution ID: **70** Type: **Submitted oral (In person)**

Evolution of Single Particle Trends Outside the N = 16 Isotones: The 27Na(d,p) Reaction at ISS.

Friday 1 December 2023 15:30 (12 minutes)

Single-particle structure has been observed to evolve away from the valley of beta-stability. In exotic nuclei, the ordering and separation between energy levels vary to the extent that nuclear magic numbers change. For example, in the neutron-rich region with Z = 8-20, the N = 20 shell closure weakens, and a new shell closure emerges at N = 16 in ^{24}O [1]. The behaviour of the negative-parity intruder states from above N = 20 are of particular interest here. The difference in the effective single particle energies (ESPE) between negative-parity orbitals and the positive-parity $d_{3/2}$ orbital defines the N = 20 shell closure. The increasing presence of negative-parity states at low excitation towards Z = 8 indicates a lowering in the ESPE of the $f_{7/2}$ and p orbitals, and therefore a weakening of the N = 20 shell closure. The proton-neutron cross-shell interactions that govern these changes in ESPE have been poorly constrained by experimental data thus far. To understand the evolution of these shell closures, and to test new shell-model interactions better tuned to the cross-shell interactions and properties of the negative-parity states, it is crucial to measure the single-particle properties of nuclei in this region.

Single-nucleon transfer reactions provide a suitable means to study single particle properties, as they selectively populate single particle states. For exotic nuclei, it is necessary to perform such reactions in inverse kinematics using radioactive ion beams. A measurement of the d(^{27}Na,p)^{28}Na reaction has been performed, using the ISODLE Solenoidal Spectrometer, to investigate the single-particle properties of the single-neutron states outside N = 16 in ^{28}Na. From this measurement, positive- and negative-parity states have been identified and a preliminary distribution of the single-particle strength in 28Na has been produced. The results can then be compared to new shell-model interactions, such as the FSU interaction [2], and further characterise the single-particle trends across the N = 17 isotones, when combined with existing data on the N=17 isotones.

This work is supported by the UK Science and Technology Facilities Council, and the U.S. Department of Energy, Office of Science, Office of Nuclear Physics, under Contract Number DE-AC02-06CH11357 (ANL), and the European Union's Horizon 2020 Framework research and innovation program under grant agreement no. 654002 (ENSAR2), and the Marie Sk lodowska-Curie grant agreement No. 665779, and the Research Foundation Flanders (FWO, Belgium), and the European Research Council under the European Union's Seventh Framework Programme (FP7/2007-2013) / ERC grant agreement number 617156.

[1] N. Tsunoda, et al., Phys. Rev. C 95, 021304 (2017).
[2] R. S. Lubna, et al., Phys. Rev. C 100, 034308 (2019).

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Session Classification: HIE-ISOLDE II