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Magicity of N=32 in neutron-rich Calcium isotopes studied via (p,pn) reaction

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In nuclei far from stability, close to the neutron dripline, shell evolution is known to give rise to intricate nuclear structure, new magic numbers and halo nuclei. The formation of a new sub-shell closure at N = 32 in the neutron-rich pf-shell nuclei was reported based on a series of observations relying on E(2+) systematics, transition probability and mass measurements. Charge radii measurements show a linear increase after N = 28 in the Calcium-chain region [1,2], which were interpreted to challenge the magic character of N = 32. Recent theoretical calculations [3] suggest that halo-like $p_{3/2}$ and $p_{1/2}$ neutron orbitals, with the size ∼0.7fm larger than $f_{7/2}$ in this neutron-rich region, could explain the observed behavior in the charge radii measurements. I will present in this talk one neutron-knockout reaction measurements performed on ^{52}Ca in inverse kinematics at ∼260 MeV/u beam energy on a 151-mm-long liquid hydrogen target at the RIBF facility. A systematic comparison of neutron-removal cross-sections from orbitals below and above shell closure, between ^{52}Ca and the well-established doubly-magic Ca-isotopes, ^{48}Ca and ^{54}Ca, corroborate the magicity of N = 32. In addition, the extracted rms of the $p_{3/2}$ and $f_{7/2}$ single-particle orbitals from the measured momentum distributions in ^{52}Ca(p,pn) reaction is in line with the theoretical calculations and supports the halo nature of the $p_{3/2}$ neutron orbital.
To summarize, our results provide direct evidence for the N = 32 subshell closure and are in agreement with a 'huge' $p_{3/2}$ neutron orbital and the increased charge radius of ^{52}Ca.

[1] Koszorús, Á., Yang, X.F., Jiang, W.G. et al. Charge radii of exotic potassium isotopes challenge nuclear theory and the magic character of N=32. Nat. Phys. 17, 439–443 (2021)
[2] Garcia Ruiz, R., Bissell, M., Blaum, K. et al. Unexpectedly large charge radii of neutron-rich calcium isotopes. Nature Phys 12, 594–598 (2016)
[3] J. Bonnard, S.M. Lenzi, and A.P. Zuker. Neutron Skins and Halo Orbits in the sd and pf Shells. Phys. Rev. Lett. 116, 212501 (2016)

Topic

Experiment

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