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Probing proton cross-shell excitations through two-neutron removal from ^{38}Ca

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The neutron-deficient calcium isotopes have attracted considerable attention recently. Present studies are divided over the amount of proton *pf*-shell occupancy, ranging from an intact $Z = 20$ shell closure [1] to a considerable weakening already in the vicinity of doubly-magic ^{40}Ca [2,3].

Two-neutron removal, a direct reaction sensitive to the single-particle configurations and couplings of the removed neutrons in the projectile wave function, from ^{38}Ca populating states of ^{36}Ca was performed at the National Superconducting Cyclotron Laboratory. Inclusive and final-state exclusive cross sections along with longitudinal momentum distributions are compared to predictions combining eikonal reaction theory and shell-model two-nucleon amplitudes [4,5].

The results yield conclusive evidence for the need of sizeable proton cross-shell excitations into the *pf* shell already for the 0_1^+ and 2_1^+ states of ^{36}Ca [6]. These findings furthermore enable a close reproduction of additional observables. Ultimately, a schematic modification of *sd* - *pf* shell gap is introduced serving as a proxy for the magnitude of proton cross-shell excitations.

[1] Miller *et al.*, Nat. Phys. **15**, 432 (2019).

[2] Caurier *et al.*, Phys. Lett. B **522**, 240 (2001).

[3] Dronchi *et al.*, Phys. Rev. C **107**, 034306 (2023).

[3] Tostevin *et al.*, Phys. Rev. C **74**, 064604 (2006).

[4] Simpson *et al.*, Phys. Rev. Lett. **102**, 132502 (2009).

[5] Beck *et al.*, Phys. Rev. C **108**, L061301 (2023).

Collaboration

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