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Investigating the N = 28 shell closure with single-nucleon transfer reactions

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The calcium ($Z = 20$) nuclides have long been considered as "textbook"shell-model nuclei, with established doubly magic isotopes at $N = 20,\ 28$ and proposed shell gaps emerging at $N = 32,\ 34$. Despite this, a growing body of evidence suggests that the shell model requires deeper investigation in this region. In ^{48}Ca, a reduction of the $f_{7/2}$ strength across the $N = 28$ shell gap was observed from neutron-knockout reactions from the $f_{7/2}$ ground states of $^{48,\ 50}$Ca.

This is inconsistent with shell-model predictions using both phenomenological effective interaction Hamiltonians like $GXPF1$ and microscopically derived $NN + 3N$ interactions in the pf model space. Furthermore, this result is also in disagreement with spectroscopic strengths determined from single-nucleon transfer reactions although the historical data here are sparse.

We will report on a first-of-its-kind simultaneous measurement of the ^{48}Ca(d, p) and ^{48}Ca(d, t) reactions with the Helical Orbit Spectrometer (HELIOS) at Argonne National Laboratory. For this experiment, HELIOS was equipped with dual Si-Arrays: the "standard" 6x4 HELIOS array positioned at $z = 900$ mm downstream to enable triton detection, and a "stub" 2x4 array at $z = 50$ mm upstream to detect protons. Additionally, a four quadrant $E\Delta E$ recoil detector with an attached ~1-m-long blocker was positioned at $z = 750$ mm downstream. This ensured the acceptance of tritons while blocking scattered, multi-orbit protons and deuterons. Preliminary results from this experiment will be discussed and compared with shell-model calculations. The importance of demonstrating the capability of simultaneous reaction studies with solenoidal spectrometers including the SOLARIS device at FRIB, will be discussed.

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