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Emerging collectivity in neutron-hole transitions near doubly magic 208Pb

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Nuclei around doubly magic ^{208}Pb have long served as a testing ground for the validity of the shell model. While the high-spin states of these nuclei have been studied extensively, data on electromagnetic transition rates between the low-spin states are scarce. Members of the $N = 125$ isotone chain – including ^{209}Po, ^{211}Rn and ^{213}Ra – exhibit a ground state with spin-parity of $J^{\pi} = 1/2^{-}$, and a $5/2^{-}$ first-excited state at near-constant excitation energy. The ground state can be attributed to a $\mathrm{p}_{1/2}$ neutron hole coupling to the 0^{+} ground-state of the neighbouring semi-magic, $N = 126$ core; likewise, coupling the ground state of the core to a $\nu f_{5/2}$ hole accounts for the excited $5/2^{-}$ state.

These nuclei have been studied using stable-beam experiments at the Australian National University Heavy Ion Accelerator Facility. Lifetimes of the $5/2-$ states in the $N = 125$ isotone chain were measured directly from γ- γ time differences using Compton-suppressed, ultrafast LaBr_3 scintillators installed in the CAESAR detector array. The near-constant excitation energy of the $5/2^{-}$ state across the chain suggests that the simple single-hole structure persists as pairs of protons are added. However, the measured $B(E2; 5/2^{-} \rightarrow 1/2^{-})$ values indicate enhanced collective contributions from valence protons that increase with Z. It appears that the near-constant $5/2^{-}$ excitation energies are a coincidental outcome of the interplay between the single-particle behaviour and emerging collectivity beyond the shell-model valence space. Shell-model calculations were performed to understand the microscopic origins of this behaviour.

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