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Single-neutron orbits near ^{78}Ni: Spectroscopy of the N = 49 isotope ^{79}Zn

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abstract

Single-neutron states in the Z = 30, N = 49 isotope ^{79}Zn have been populated using the ^{78}Zn(d, p)^{79}Zn transfer reaction at REX-ISOLDE, CERN. The experimental setup allowed the combined detection of protons ejected in the reaction, and of γ rays emitted by ^{79}Zn. The analysis reveals that the lowest excited states populated in the reaction lie at approximately 1 MeV of excitation, and involve neutron orbits above the N = 50 shell gap. From the analysis of γ-ray data and of proton angular distributions, characteristic of the amount of angular momentum transferred, a $5/2^+$ configuration was assigned to a state at 983 keV. Comparison with large-scale-shell-model calculations supports a robust neutron N = 50 shell-closure for ^{78}Ni. These data constitute an important step towards the understanding of the magicity of ^{78}Ni and of the structure of nuclei in the region.

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Shell structure characterizes several many-body systems of fermions moving in a common potential, such as atomic electrons, metal clusters and nuclei. Angular momentum quantization induces a bunching of the single-particle states, resulting in shells separated by energy gaps. In the nuclear medium, such shell gaps are revealed by nuclei with neutron and proton numbers corresponding to closed-shell configurations. The properties of these so-called magic nuclei and of their neighbors, which were cardinal to the development of the nuclear shell model, could only be reproduced when the role played by the nuclear spin orbit interaction was recognized [1].

In recent years, experiments with radioactive ion beams have shown that in some neutron-rich nuclei well-established shell closures can vanish, and new magic numbers appear [2,3]. The challenge to explain and predict the size of shell gaps away from beta stability has led to considerable progress in nuclear physics, both experimentally and theoretically. Despite some remarkable steps forward in describing the evolution of shell structure, e.g. the inclusion of the tensor interaction [4] and three-body forces [5,6], rare-isotope data are still essential to test and guide theoretical advances. Nuclei away from the valley of beta stability with magic numbers