High-Spin γ-Ray Spectroscopy in the Vicinity of ^{56}Ni

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The nuclei located around the doubly magic shell gap $N = Z = 28$ have been extensively studied with light ion induced reactions (e.g. Ref. [1] for the isospin $T_z = +1/2$ nucleus ^{55}Co). With a proton scattering experiment in inverse kinematics the $B(E2; 2^+ \rightarrow 0^+)$ in ^{56}Ni was measured recently [2,3], and the comparatively large value can be explained by the attractive interaction of $1f_{7/2}$ holes and $1f_{5/2}$ or $2p_{3/2}$ particles. However, high-spin spectroscopy in that mass $A \approx 60$ region has eked out a shadowy existence until now. Even though ground-state γ-ray transitions were reported for most of the nuclei, the excitation schemes comprise rather few high-spin levels — at most 5 to 10 if not fewer. Particular research objectives in that mass region are constraints on the spherical shell-model parameters, the observation of the predicted normally deformed and possibly superdeformed rotational bands, influence of the $T = 0$ pairing in (odd-odd) $N = Z$ systems, or the test of the isospin symmetry in medium-mass mirror nuclei.

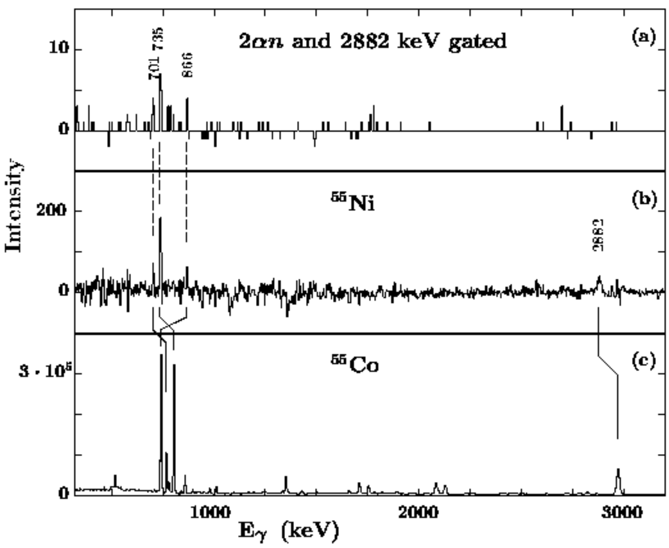

Fig. 1: Gamma-ray spectra from the reaction ^{36}Ar+^{28}Si.

We performed an experiment using the heavy-ion induced reaction ^{36}Ar + ^{28}Si at 136 MeV beam energy at the GAMMASPHERE facility in conjunction with ancillary detectors to measure the evaporated neutrons, protons, and α-particles. Nearly $2 \cdot 10^9$ and $3 \cdot 10^8$ two- to four-fold gamma events were collected with thin and Ta-backed targets, respectively. The first experimental results include the identification of γ rays originating from the $T_z = -1/2$ nucleus ^{55}Ni. This nucleus is produced via ^{28}Si(^{36}Ar,2αn)^{55}Ni with an experimental relative cross-section of $\sigma_{\rm rel} \approx 0.004$ %. The middle panel of Fig. 1 shows a purified singles spectrum gated by two evaporated α-particles and one neutron. Contaminations from higher fold charged-particle channels (e.g. ^{54}Co+2αpn) or small target impurities (< 1 % ^{29,30}Si) were subtracted. Some 200 counts are left in the peak of the 2882 keV ground-state transition which corresponds to a channel selection of the set-up in the order of 10^{-7}.

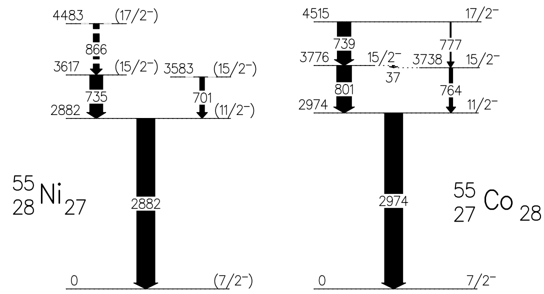

Fig. 2: Partial excitation schemes of ^{55}Ni and ^{55}Co.

The excitation energy of 2882 keV might correspond to a state at 2888(7) keV observed in the ^{58}Ni(^{3}He,^{6}He)^{55}Ni reaction [4]. The top panel provides a spectrum gated by the 2882 keV γ-ray in a 2αn-gated $\gamma\gamma$ matrix. The γ-rays at 701, 735, and 866 keV are in coincidence with the gating transition. The bottom panel shows the "pure" 2αp-gated spectrum of the $T_z = +1/2$ nucleus ^{55}Co. The mirror symmetry of the two $A = 55$ $T = 1/2$ nuclei can clearly be seen in the spectra, but more obviously in the level schemes which are presented in Fig. 2. Only three transitions were reported previously for ^{55}Co. Our preliminary extended level scheme comprises some 70 γ rays connecting some 35 near yrast levels up to a spin of $I \approx 18$ $\hbar$ at 15 MeV excitation energy. Completely aligned seniority $v = 7$ configurations in the fp shell are compatible with these values. Other results are extended level schemes of the odd-odd $N = Z$ nuclei ^{54}Co and ^{58}Cu aiming at the $T = 0$ two-body matrix-elements of a np hole or np pair relative to ^{56}Ni.

References

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