

Positive and Negative Parity Band Structures in ^{57}Ni

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Introduction

The nuclear structure study of odd-A and odd-odd nuclei near the vicinity of the doubly-magic ^{56}Ni is the subject of contemporary research interest. Our previous studies on ^{59}Ni , ^{57}Fe , ^{56}Co and ^{54}Mn reveal the evidence of the presence of different structural phenomena, including chiral doublet bands, magnetic rotational band, gamma vibration, octupole correlation and deformed band due to the shape-driving effect of the intruder $g_{9/2}$ orbital [1–4]. In the present work, we present here our recent results on ^{57}Ni , the nearest odd-neutron neighbour of ^{56}Ni . The previous study of this nucleus reported some evidences of rotational band structures in this nucleus by populating the excited states by near-symmetric heavy-ion fusion evaporation reaction [5].

In the present work, we have employed

TABLE I: DCO (E2 gated) & Polarization asymmetry ratios for few γ s in ^{57}Ni .

E_γ (keV)	E_{level} (keV)	R_{DCO}	Δ_{asym}	TYPE
1287	3864	1.00 (3)	0.063 (4)	E2
1124	3701	0.71 (4)	0.045 (6)	E1
1614	5315	1.16 (21)	-0.058 (25)	M1+E2
1723	7038	1.07 (33)	0.021 (14)	E2
2457	6158	1.06 (13)	-0.041 (19)	M2

light-ion (α) induced reaction for its study which provided a wealth of information, particularly for the non-yrast states.

Experiment

The $^4\text{He} + ^{58}\text{Ni}$ reaction with 37 MeV α beam from K-130 cyclotron at VECC was used to populate the excited states in ^{57}Ni . A thick (18 mg/cm²), 99.48% enriched self supporting foil was used as target.

INGA setup, with 11 HPGe clovers (2 at 40°, 6 at 90°, 3 at 125°) and a LEPS (at 40°), was used for collecting two or higher fold $\gamma-\gamma$ coincidence data with the help of a PIXIE-16 based digital data acquisition [6].

Results and Discussion

The in-house developed sorting code BiNDAS [7] was used to create all-detectors vs. all-detectors symmetric matrix and asymmetric matrices for DCO ratio (R_{DCO}) and polarization asymmetry (Δ_{asym}) measurements. Values of R_{DCO} and Δ_{asym} for a few crucial γ s are given in Table I. A partial level scheme of ^{57}Ni , obtained from the present work, is shown in Fig. 1(a). A positive parity band, based on $9/2^+$ band head, with possible $g_{9/2}$ configuration, has been identified. The $J^\pi = 9/2^+$ is established from the E1 nature of the 1124-keV transition (see Table I). A new negative parity band, based on the 2^{nd} $7/2^-$ state, has also been identified from the placement of a new 1012 keV γ (Fig.1(b)). The bands B1 and B2

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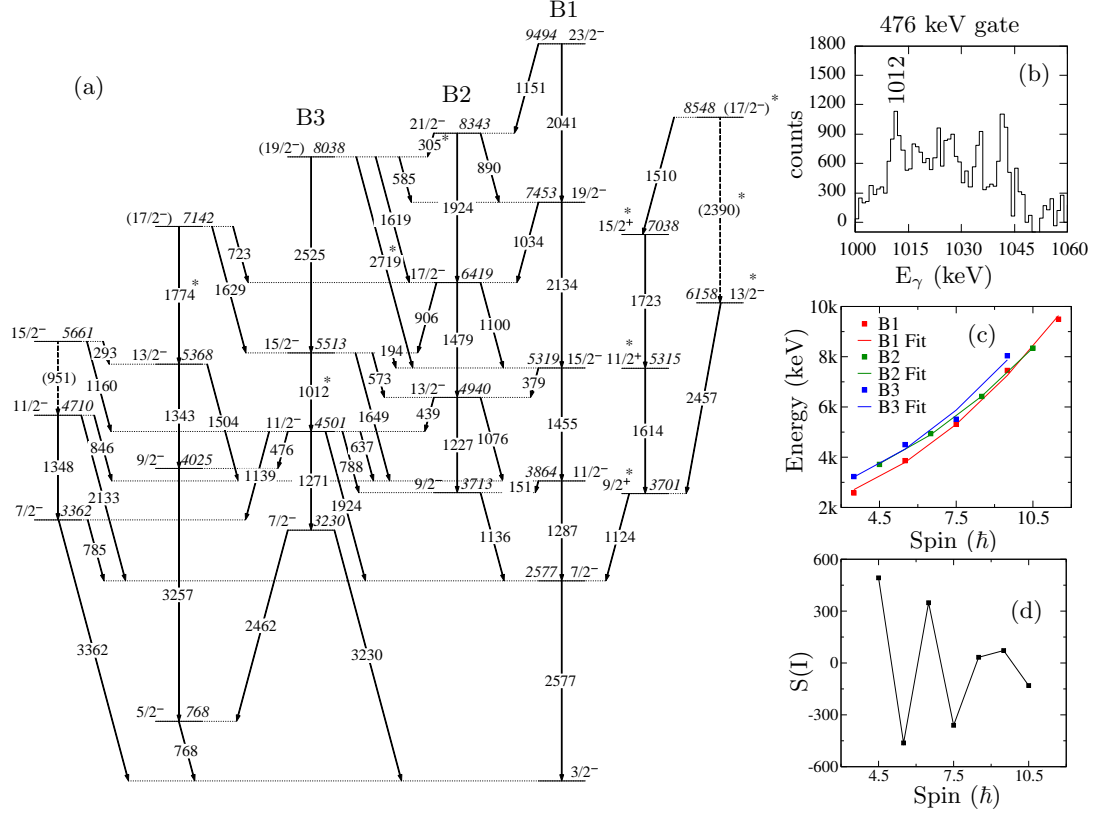


FIG. 1: (a) Partial level scheme of ^{57}Ni from the present work. New spin parities and transitions are marked by “*”, (b) gate on 476 keV γ - transition showing 1012 keV transition, (c) Energy vs. Spin for Band B1, B2 and B3, (d) Staggering vs. Spin for B1 and B2

resemble the signature partners of deformed rotational band from the fitting to their E_x vs. J plot (Fig.1(c)) by the rotational model formula ($E_{level} = A_0 + A_1 * J * (J + 1)$) and staggering ($S(I)$) plot (Fig.1(d)). The band B3 also possesses similar moment of inertia (Fig.1(c)). Several connecting transitions between the bands B1, B2 and B3 have been identified. Each state in B3 decays to both B2 and B1 by 3 connecting transitions with spin differences of $\Delta J = 0, 1$ and 2.

Conclusion

A new level scheme of ^{57}Ni has been obtained with several new information. The positive parity band, with $g_{9/2}$ configuration, and a new negative parity band with interconnecting transitions, have been established for the first time. The results suggest possible evidence of triaxial shape in ^{57}Ni . Details will be

presented in the symposium.

Acknowledgment

We thank the cyclotron staff at VECC for good quality α beam.

References

- [1] S.S. Nayak et al., Proc. DAE Symp. Nucl. Phys. **65**, 134 (2021).
- [2] S. Basu et al., Proc. DAE Symp. Nucl. Phys. **67**, 101 (2023).
- [3] S.S. Nayak et al., Proc. DAE Symp. Nucl. Phys. **67**, 49 (2023).
- [4] S. Basu et al., EPJ **A 59** 229 (2023).
- [5] D Rudolph et al., JPG **37**, 075105 (2010).
- [6] S. Das et al., NIM **A 893**, 138 (2018).
- [7] S.S. Nayak and G. Mukherjee, IEEE Trans. Nucl. Sc. **70**, 2561 (2023).