

Investigation of structural evolution in ^{70}Ge

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Introduction

The even-even nuclei play a crucial role for understanding the pairing break-up and corresponding existence of different exotic phenomena in their level structure. In this scenario the ^{70}Ge nucleus exhibits a perfect situation, just like ^{152}Dy , where a variety of symmetry breaking phenomena have been expected to be observed in the level structure.

The ^{70}Ge nucleus was previously studied by using ^{12}C beam extending the level structure up to ~ 10 -MeV [1]. Very recent work revealed the high-spin states in ^{70}Ge that were populated from the $^{55}\text{Mn}(^{18}\text{O}, p2n)$ reaction at a beam energy of 50-MeV and reported the assignment of 31 new transitions and a rearrangement of four others, when compared to the previously published works, enhancing the known level scheme with both positive- and negative-parity states organized into multiple band structures [2]. Though, high-spin structure, obtained from these investigations are overlapped, the low-spin structures are not explored yet. With this motivation, to investigate the low-spin states along with the several exotic phenomena the ^{70}Ge nucleus has been populated and subsequently studied using the reaction of ^9Be with the ^{64}Ni . Several newly observed band-like structures have been observed with similar spin and excitation energy representing their exotic character.

Experimental details and analysis

The experiment was performed using ^9Be beam (current ~ 5 nA) at an energy of 30-MeV obtained from the Pelletron Linac Facility at Mumbai. A self-supporting foil of ^{64}Ni of

thickness ~ 500 $\mu\text{g}/\text{cm}^2$ was used as the target. The de-exciting γ -rays emitting from the residual nucleus ^{70}Ge from 3n evaporation channel were detected using the γ -detector setup consisting of 14 Compton-suppressed Clover detectors placed at 40° , 90° , 140° , 115° and 157° with respect to the beam direction. Data were recorded in list mode in a digital data acquisition system (DDAQ) based on Pixie-16 modules of XIA-LLC, which provides both energy and timing information. The γ -ray data were sorted using Multi parameter time stamped based Coincidence Search (MARCOS) [3] program to generate one dimensional histograms, γ - γ matrix, and γ - γ - γ cube for offline analysis. RADWARE software package were used for subsequent analysis.

Results and Discussions

The proposed partial level scheme obtained from the present γ - γ coincident measurement has been depicted in Fig.1. This level scheme is in agreement with the structures presented by the previous investigations. The level scheme has been extended up to an excitation energy ~ 10 -MeV and a tentative spin (16) by placing more than twelve gamma transitions.

The ground state band has been observed to fragments over various cascades; three of them are completely new. A sequence of 1427, 968 and 1166-keV transitions have been observed but not in the other members of the ground state band. A typical gated spectrum of 1427-keV, as shown in Fig. 2, exhibits the 1038, 1112, 968 and 1166-keV transitions. Thus, the new sequence has been placed above the 1112-keV in coincidence to the 1038 and 1112-keV transition but not in the other members of the ground state band. A typical gated spectrum of

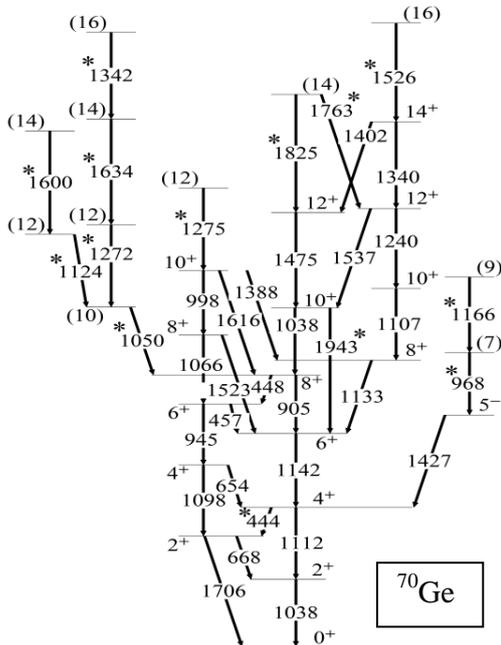


Fig. 1. Proposed partial level scheme of ^{70}Ge .

1427-keV, as shown in Fig. 2, exhibits the 1038, 1112, 968 and 1166-keV transitions. Thus, the new sequence has been placed above the 1112-keV transition and parallel to the 1142-keV transition.

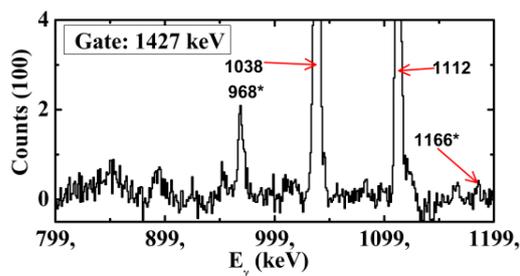


Fig. 2. The γ - γ coincidence spectrum for the 1427-keV transition. The newly observed transitions are marked by an asterisk

Above the 10^+ state, depopulated by the 905-keV transition, of the ground state band two newly observed band-like structures have been identified. These two bands are connected to the ground band through the 1050-keV transition. In the gated spectrum of 905-keV transition the newly observed gamma rays of energy 1050,

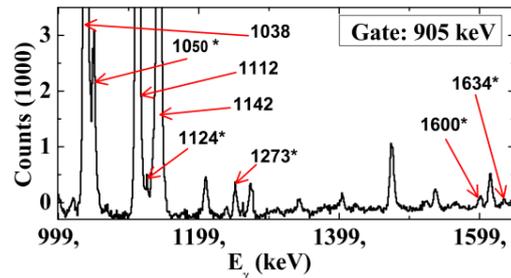


Fig. 3. The γ - γ coincidence spectrum for the 905-keV transition. The newly observed transitions are marked by an asterisk

1272, 1342, 1600, 1124, 1634-keV have been observed as shown in Fig. 3. The 1272, 1342 and 1634-keV transitions are in coincidence to each other, thereby constitute a band-like structure as shown in Fig. 1. Other two transitions (1124 and 1600-keV) are in coincidence with the 1050-keV transitions and the low lying gamma rays but remain absent in the gated spectrum of 1272, 1342 and 1634-keV transitions. Thus, the 1124 and 1600-keV transitions have been placed above the 1050-keV transition and parallel to the 1272-keV transitions, as shown in Fig. 1. In addition to these transitions, another transition of energy 1824-keV is observed in coincidence with the all transitions in the ground state band. Thus, this transition has been placed at the top of this band. Several other transitions viz. 444, 1526, 1763 and 1943-keV have been placed in the level structure. The details of the analysis along with the theoretical calculations are in progress.

The level structure of the ^{70}Ge exhibits a unique feature of vibrational states at low spin whereas band-like sequences have been observed at high spin (Fig. 1). Thus it may be concluded that the structural evolution with angular momentum occurs in ^{70}Ge .

References

- [1] M. Sugawara, et al., Phys. Rev. C 81, 024309 (2010).
- [2] R. A. Haring-Kaye, et al., Phys. Rev. C 97, 024308 (2018).
- [3] R. Palit, et al., Nucl. Instrum. Methods A 680,90 (2012).