Structural Analysis of ^{57,59}Co

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Introduction

The present day research is mainly focussed on the study of nuclei lying in the vicnity of the magic nuclei. This is taken as the challenge by both experimentalists as well as theoreticians because of the fact that due to the presence of deformation in their shell structure, the nuclei present in the neighborhood of the magic nuclei offer interesting laboratory for their study and also give an idea of understanding new facets of nuclear structure. For example, it is well known that the addition or removal of one or more nucleons from the magic core, Ni, lead to the disappearance of the magicity and thus offers a wide view point to study the various nuclear strucure phenomena present in the neighboring nuclei.

Because of a rich variety of phenomena exhibited by these neighbouring nuclei, it is a challenging and interesting task to describe these nuclei from a single deformed Nilsson potential. One of the best candidates in the neighborhood of Ni, having one proton less than the Ni nuclei, is Co, which forms a connection between the spherical Ni isotopes and the region of deformation below Z=28. One of the reliable methods that use various interaction terms in its Hamiltonian, such as monopole pairing interaction, quadrupole pairing interaction and quadrupole-quadrupole interaction, is the Projected Shell Model (PSM), which successfully explains the high spin structure of the nearly deformed nuclei. Hence, in the present work, a structural analysis of the odd mass ^{57,59}Co isotopes has been made and some important nuclear structure properties of these isotopes have also been discussed.

Framework used in the present work

In the present work, the calculations of the negative-parity yrast energy levels of odd mass ^{57,59}Co isotopes have been carried out by using PSM approach. Besides this, some of the nuclear structure properties like intrinsic quasi-particle band structure as well as the reduced transition probabilities [*B(E2)*] of these isotopes have also been obtained. However, due to the page limit of the abstract, the research results are presented for only one isotope i.e., ^{57}Co, whereas the complete set of research results would be discussed during the session of the symposium. The detailed description of applied framework PSM can be found in review article [1]. Projected shell model is the natural extension of the shell model which basically begins with the deformed Nilsson single-particle states at a deformation ε_2. It makes use of angular-momentum projection technique in order to project out energies from the deformed Nilsson basis and hence makes shell model type of calculations possible for deformed nuclei. Pairing correlations are incorporated into the Nilsson states by BCS calculations. Finally, a two-body shell model Hamiltonian is diagonalzed in the projected basis thereby obtaining the energy levels for a given spin. A brief account on the Hamiltonian used along with the important input parameters used in the present calculations is given hereunder. The Hamiltonian used for making calculations of the odd mass Co nuclei is

$$\hat{H}_{QP} = \mathrm{H_o} - \frac{1}{2}\chi\sum_{\mu} \hat{Q}^{\dagger}_{\mu}\hat{Q}_{\mu} - G_M \hat{P}^{\dagger}\hat{P} - G_Q\sum_{\mu}\hat{P}^{\dagger}_{\mu}\hat{P}_{\mu}$$

where $\mathrm{H_o}$ represents the spherical single particle shell model Hamiltonian, involving spin-orbit interactions while the second term includes the quadrupole-quadrupole interaction and third and fourth terms denotes the monopole and quadrupole pairing interactions respectively. The strength of these two body quadrupole interaction is described by the parameter χ which is adjusted so that quadrupole deformation ε_2 is obtained. In the present PSM calculations, we have used three major shells (N=1, 2, 3) for protons and (N=2, 3, 4) for neutrons. The shell model space is truncated at a deformation $\varepsilon_2 \sim -0.248$ for these isotopes.

Results and Discussions

Here, we have presented the calculated yrast energy levels, band structure and the *B(E2)* values for the ^{57}Co nucleus and these results have been displayed in Figs. 1, 2 and 3 respectively along with their available experimental counterparts. On comparing PSM results for the yrast levels with the experimentally available data, an overall good agreement has been found. Regarding the band structure of ^{57}Co nucleus, it has been seen from the Fig. 2 that for the lower spins, yrast band is reproduced by one quasi-particle bands only with band-heads K= 5/2 and -3/2 whereas, for higher spin states, three quassi-particle bands with band-heads K= -1/2 contribute to the formation of yrast band.

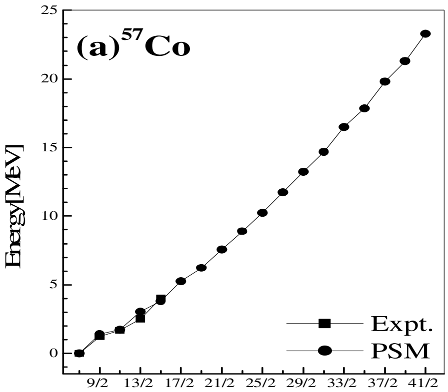

Fig. 1 Negative-parity yrast band in ^{59}Co. Experimental data is taken from [2].

Besides this, the calculated *B(E2)*'s for ^{57}Co nucleus are shown in Fig.3. From this fig. it is clear that the calculated *B(E2)*'s are in good agreement with the available experimental data

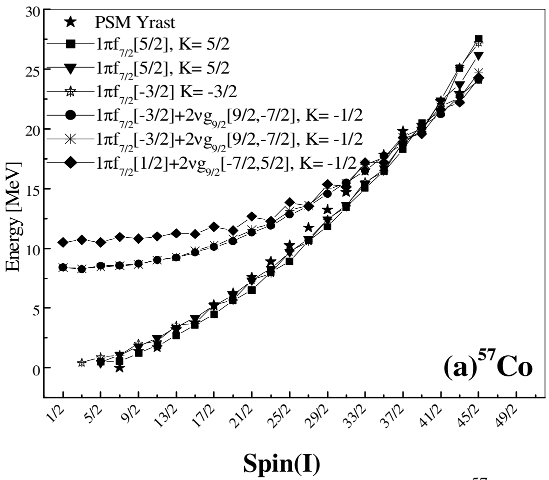

Fig. 2 Quasi-particle configuration of ^{57}Co

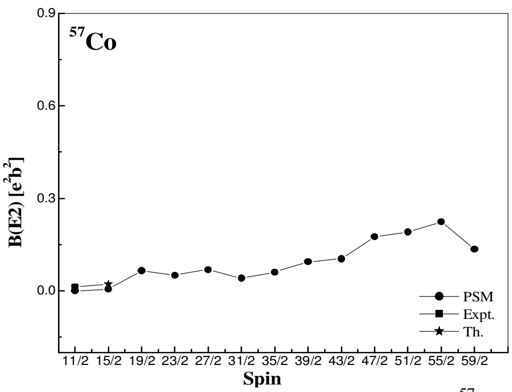

Fig. 3 *B*(*E2*) values for yrast bands in ^{57}Co isotope. Other exp. and theoretical data is taken from[3].

Summary

To summarize, it has been found that PSM technique provides a good description of the high spin states of these ^{57,59}Co isotopes. When calculated results are compared with the experimental as well as the other theoretical data, a reasonable agreement is obtained which successfully tests the reliability and applicability of the applied Projected Shell Model.

References

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