Rotation particle coupling in odd-odd nuclei using the coupling matrix approach

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Introduction

A reasonable theoretical basis is provided by the particle rotor model (PRM) for the study the observed rotational spectra of several strongly deformed nuclei. This model describes the low lying rotational bands of the nuclei quite well with the assumption that the single-particle moves in a potential generated by the core. This idea, in the strong coupling limit has been extensively discussed in the literature [1, 2]. In many cases, the core may exhibit deviation from the rigid-rotor behaviour and in such cases a variable moment of inertia (VMI) is employed to achieve better fit with experimental data. The VMI is fitted to reproduce the core spectrum. In the PRM, the core angular momentum is not a part of the basis and hence the VMI is treated as a function of total angular momentum ($\vec{I} = \vec{R} + \vec{j}$). In such cases the high spin states are spuriously lowered and hence determining the low lying states could be erroneous.

A better approach is the coupling matrix approach which successfully explains the rotational spectra despite the deviation from rotational behaviour of the core [3, 4]. In the present work, we have extended this approach to study rotation particle coupling in odd-odd nuclei. As an application of our approach, we discuss the rotational spectra of the proton emitter ^{170}Au.

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Formalism

To calculate the eigenvalues and the wavefunctions of odd-odd nuclei, we consider the valence nucleons to be moving in the deformed mean field of Woods Saxon potential along with proper treatment of pairing and residual neutron proton interaction [5, 6]. The total hamiltonian for the system is the sum of intrinsic part and rotational part, and can be written as $H = H_{av} + H_{pair} + V_{np} + H_R$. The corresponding matrix elements can be obtained as

$$\langle K'_T, IM|H|K_T, IM\rangle = (\epsilon_p + \epsilon_n)\delta_{K_T K'_T} + \sum_{lj} \mathbb{W}^{jI}_{K_T K'_T} \times \int dr\ \phi^{IK'_p *}_{l_p j_p}(r)\ \phi^{IK_p}_{l_p j_p}(r) \int dr\ \phi^{IK'_n *}_{l_n j_n}(r)\ \phi^{IK_n}_{l_n j_n}(r),$$

where $\epsilon_{(p,n)}$ are the quasi particle energies, ϕ represents the radial wavefunctions and $\mathbb{W}^{jI}_{K_T K'_T}$ is the coupling matrix. In this approach we evaluate the matrix element $\langle K'_T, IM|H_R|K_T, IM\rangle$ in the K-representation by utilizing the core energies E_R of neighbouring even-even nucleus as:

$$\langle ljK'_T, IM|H_R|ljK_T, IM\rangle = \sum_R C^{IK'_T}_{j,R}\ E_R\ C^{IK_T}_{j,R} = \mathbb{W}^{jI}_{K_T K'_T},$$

where the $C^{IK_T}_{j,R}$ are amplitudes defined as

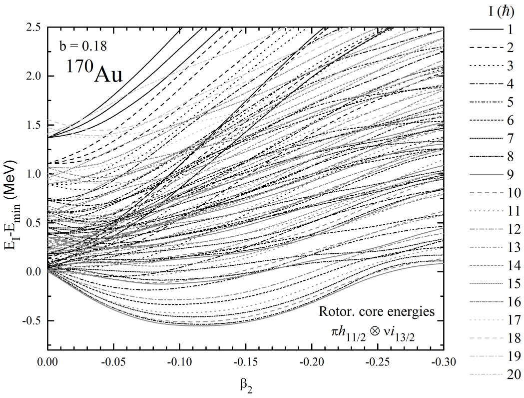

FIG. 1: Rotational states of ^{170}Au obtained from the variable moment of inertia (VMI) approach.

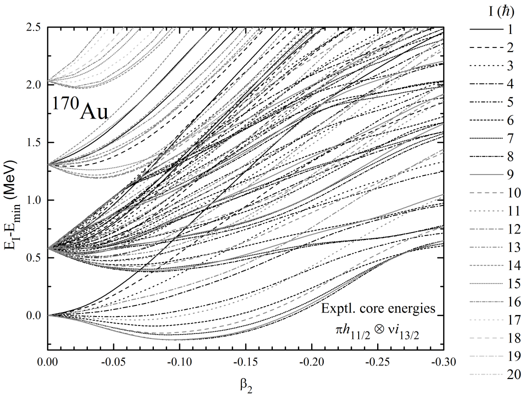

FIG. 2: Rotational states of ^{170}Au obtained from the coupling matrix approach. At $\beta_2 = 0$, the energy levels degenerate to the experimental energies of the core.

$$C^{IK_T}_{j,R} = \sqrt{\frac{2R+1}{2I+1}} \langle jK_T R0 | IK_T \rangle \langle j_p K_p j_n K_n | jK_T \rangle .$$

Result and discussions

We report here the results for the proton emitting nucleus ^{170}Au, whose low lying states are ambiguously assigned. In this case, measured spectrum of the core ^{168}Pt , deviates considerably from a pure rotor pattern. The rotational energies of the two quasiparticle plus rotor are calculated by considering mixing between the proton levels from $h11/2$ and neutron levels from $i13/2$. In a VMI approach, a strong VMI parameter ($b = 0.18$) is required to fit the spectrum of the core. This leads to spurious lowering of several states as shown in Fig. 1. In Fig. 2, the results from the coupling matrix approach are presented. Here we see that there is no spurious lowering of states and the degeneracy at zero deformation also comes out naturally.

In summary, we have applied a new method for studying rotational states in deformed odd-odd nuclei. This would be useful approach to study the ground and low-lying states, especially at the drip lines, where the experimental data are scarce. Work is in progress to implement this method to study the proton emission and other decay properties in deformed odd-odd nuclei.

Acknowledgments

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