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High-spin doublet band structures in odd–odd $^{194-200}$Tl isotopes

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Abstract The basis space in the triaxial projected shell model (TPSM) approach is generalized for odd–odd nuclei to include two-neutron and two-proton configurations on the basic one-neutron coupled to one-proton quasiparticle state. The generalization allows to investigate odd–odd nuclei beyond the band crossing region and as a first application of this development, high-spin band structures recently observed in odd–odd $^{194-200}$Tl isotopes are investigated. In some of these isotopes, the doublet band structures observed after the band crossing have been conjuctured to arise from the spontaneous breaking of the chiral symmetry. The driving configuration of the chiral symmetry in these odd–odd isotopes is one-proton and three-neutrons rather than the basic one-proton and one-neutron as already observed in many other nuclei. It is demonstrated using the TPSM approach that energy differences of the doublet bands in ^{194}Tl and ^{198}Tl are, indeed, small. However, the differences in the calculated transition probabilities are somewhat larger than what is expected in the chiral symmetry limit. Experimental data on the transition probabilities is needed to shed light on the chiral nature of the doublet bands.

1 Introduction

High-spin spectroscopy has played a pivotal role to unravel the structure of atomic nuclei at high angular momentum and excitation energy [1]. The advancements in the spectroscopic techniques have allowed to probe the properties of nuclei in regions that were hitherto inaccessible. The band structures have been identified up to very high angular momentm and excitation energy and data has revealed interesting phase and shape transitions [2]. In odd–odd nuclei, the energy spectrum is quite rich as compared to even–even and odd-mass nuclei due to extra neutron–proton coupling. Recently, in odd–odd $^{194-200}$Tl isotopes, band structures have been populated beyond the first band crossing and it has been spectulated that near degeneracy of the yrast and the side band energies, observed in some of these isotopes, may be a consequence of the chiral symmetry breaking mechanism [3–6]. In these isotopes, band structures have one-proton and three-neutron, $\pi h_{9/2} \otimes \nu i^{-3}_{13/2}$ configuration at higher spins and one-proton and one-neutron, $\pi h_{9/2} \otimes \nu i^{-1}_{13/2}$ configuration at lower spins.

Chiral symmetry has been studied quite extensively in triaxial deformed nuclei [7–10]. In the original work, the chiral symmetry mechanism was proposed for odd–odd nuclei with the angular-momentum of the odd-proton and odd-neutron aligned towards short- and long-axis, and the angular-momentum of the deformed core projected towards the intermediate axis [11]. As the clock-wise and the counter clock-wise rotation of the three orthogonal vectors are equivalent, this results into doublet band structures with identical spectroscopic properties. Doublet bands with similar properties have been observed in several mass regions of the periodic table [12–16], including the A $\sim$ 80 region in recent works[17–19]. Chiral symmetry breaking has also been proposed in odd-mass [16,20] and even–even nuclei [21]. Theoretically, several nuclear models have been employed to investigate the chiral symmetry breaking mechanism, which include both microscopic and phenomenological models [22–26]. Triaxial projected shell model (TPSM) approach, a semi-microscopic model, has been used to elucidate the band structures in deformed and transitional nuclei [27]. It has been demonstrated that the properties of the observed doublet bands are reproduced quite successfully using the

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