Neutron alignments in the yrast band of ^{199}Tl

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Introduction

Isotopes of Tl ($Z = 81$) display a variety of nuclear structure phenomena. Though they have only one valence proton with respect to the proton magic number at $Z = 82$, the lighter isotopes ($N \leq 120$), exhibit some extent of collective behavior on account of the presence of six or more valence neutrons, in contrast to the heavier ones which display intrinsic behavior and the presence of isomeric states. In the lighter Tl isotopes, phenomena ranging from possible shears and chiral bands up to superdeformation at very high spin, have been reported. The isotope ^{199}Tl ($N = 118$) lies in the transitional region where both intrinsic and collective excitations play a role, and it is of interest to investigate the interplay between these two mechanisms.

Experiment

Earlier reports on ^{199}Tl include the study of this nucleus with ^{7}Li and alpha beams [1, 2] resulting in the identification of levels up to 33/2 $\hbar$ built on the 1-quasiproton, $\pi h_{9/2}$ state, from above the $Z = 82$ shell gap [3, 4]. The population of ^{199}Tl from fusion-evaporation reactions with quite heavy-ion stable beams is unfeasible, therefore the high-spin structure was yet unexplored. In the present work, ^{199}Tl was populated up to quite high spin through multinucleon transfer between the 1450-MeV ^{209}Bi projectile from the ATLAS accelerator at the Argonne National Laboratory and a thick target of ^{197}Au. Three- and higher-fold γ-ray coincidence data were recorded using the Gammasphere detector array which comprised of 100 HPGe detectors. The data were sorted into a number of different histograms and analyzed using the Radware suite of programs [5, 6].

Results and Discussion

The detailed coincidence analysis led to the extension of both the negative- and positive-parity sequences up to $\approx 25\ \hbar$ in ^{199}Tl, with the inclusion of many newly-placed γ rays. Weakly deformed oblate band structures with transitions having both $\Delta I = 1$ and $\Delta I = 2$ character were observed. Observables like the moment of inertia, aligned angular momentum, B($M1$)/B($E2$) ratios etc. were extracted from the experimental data. The $\Delta I = 1$ transitions were found to be more prominently visible in comparison to the crossover $\Delta I = 2$ ones in the negative-parity sequence. Additionally, abrupt discontinuities were evident in the moment of inertia of the band. Since this may either be attributed to a small amount of collectivity with significant contributions from aligned angular momentum, or the realization of magnetic rotation, both possibilities were explored using Tilted Axis Cranking (TAC) and Principal Axis Cranking (PAC) calculations. The latter were performed using the Ultimate Cranker (UC) code [7].

While the TAC calculations were able to give a reasonable account of the 3-quasiparticle (qp) and 5-qp energies in the yrast band, the agreement between experimental and calculated B($M1$)/B($E2$) values

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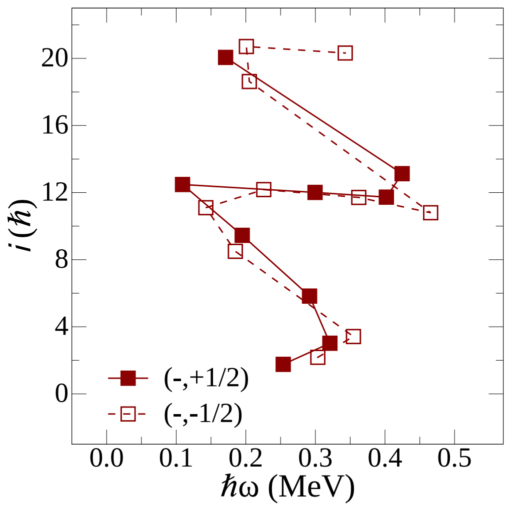

FIG. 1: Aligned angular momentum as a function of rotational frequency for the negative-parity, yrast band in ^{199}Tl.

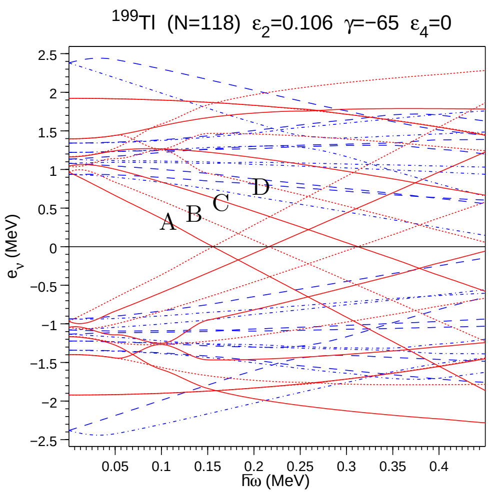

FIG. 2: Neutron quasiparticle levels in ^{199}Tl from UC calculations.

was not as satisfactory. The UC calculations, on the other hand, are able to account for the observed band crossing frequencies, the experimental values of which are inferred to be 0.21 MeV and 0.30 MeV (Fig. 1), with the calculated ones being 0.18 MeV and 0.27 MeV (Fig. 2) for the neutron $i_{13/2}$ AB and CD crossings. The UC calculations indicate an oblate deformation ($\epsilon_2 = 0.106$ and $\gamma = -65^\circ$ at $I^\pi = 21/2^-$) which persists for most of the spin range, evolving to more negative γ values beyond 45/2 $\hbar$. The descriptive power of the TAC calculations in this case may be limited on account of the fact that considerable alignment of quasiparticle angular momentum occurs at rather low frequencies. The detailed experimental data, observables inferred thereof, and results of the TAC and UC calculations will be presented at the symposium.

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