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Low-Spin Signature Inversion in the $\pi h_{9/2}\otimes\nu i_{13/2}$ Oblate Band*

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Abstract Excited states in ^{188,190}Tl have been studied experimentally by means of in-beam γ spectroscopy techniques, and resulted in the identification of a strongly coupled band based on the $\pi h_{9/2}\otimes\nu i_{13/2}$configuration with oblate deformation. The oblate band in doubly odd Tl nuclei shows low-spin signature inversion. It is the first experimental observation of low-spin signature inversion for a band associated with the oblate $\pi h_{9/2}\otimes\nu i_{13/2}$ configuration.

Key words γ-γ-coincidence, rotational band, signature inversion

The so-called low-spin signature inversion has been systematically observed in the rotational bands of odd-odd nuclei throughout the chart of nuclides[1, 2]. The theoretical studies have suggested that the occurrence of signature inversion is associated closely with the positions of the Fermi surfaces of nucleons[1, 3] and the configurations of states[4]. Therefore, the observation of signature inversion bands in new mass region and with new configurations is very important for a deeper understanding of the low-spin signature inversion phenomenon and to examine the theoretical models with different physical pictures. In this paper, we report on the first observation of low-spin signature inversion in the oblate $\pi h_{9/2}\otimes\nu i_{13/2}$ band in ^{188,190}Tl.

Standard in-beam γ spectroscopy measurements were performed via the ^{160}Gd (^{35}Cl, 5n) and ^{157}Gd (^{35}Cl, 4n) reactions for ^{190}Tl and ^{188}Tl, respectively. Assignments of the observed γ rays to ^{188,190}Tl were based on the coincidences with the known γ rays[5]. On the basis of the analysis of the γ-γ coincidence relationships, rotational bands for ^{188,190}Tl are proposed and shown in Fig.1. Combining the results of α-γ correlation measurements in the decay of ^{194}Bi[6] with the measured DCO and γ-ray anisotropy results, we have proposed the spin and parity for the rotational band of ^{190}Tl. Although rotational bands based on the $\pi h_{9/2}\otimes\nu i_{13/2}$ oblate configuration were observed in doubly odd $^{192-200}$Tl nuclei[7], their spin assignments have been remained uncertain due to experimental difficulties. Considering the similarity between the bands observed in odd-odd Tl nuclei, it is now reasonable to determine spin values for the $\pi h_{9/2}\otimes\nu i_{13/2}$bands observed in $^{192-200}$Tl. Fig. 1 also

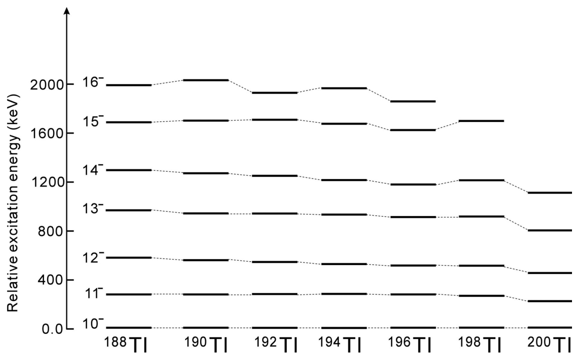

Fig. 1. Systematic of the level structure in the odd-odd $^{188-200}$Tl nuclei.

summarizes the presently available $\pi h_{9/2}\otimes\nu i_{13/2}$ oblate bands in odd-odd Tl nuclei. If we adopted new spin assignments for the bands in odd-odd $^{192-200}$Tl as suggested in Fig. 1, the systematic of the level

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structure in the odd-odd Tl nuclei is very remarkable, i.e., the ΔI=2 energy spacings and the energy staggering between the odd and even spin members vary very smoothly from A=188 to 200.

An interesting phenomenon concerning the oblate bands in doubly odd $^{188-200}$Tl nuclei is the low-spin signature inversion; the expected $\alpha_{\mathrm{p-n}}(f) = \alpha_{\mathrm{p}}(f)+\alpha_{\mathrm{n}}(f) = 1/2+1/2 = 1$ favored signature branch lies higher in energy than the $\alpha_{\mathrm{p-n}}(uf) = \alpha_{\mathrm{p}}(uf)+\alpha_{\mathrm{n}}(f) = 1/2-1/2 = 0$ unfavored signature branch. Fig. 2 presents plots of the signature splitting for the $\pi h_{9/2}\otimes\nu i_{13/2}$ oblate band in $^{188-198}$Tl, defined as

$$S(I)=E(I)-[E(I+1)+E(I-1)]/2\ .$$

Here $E(I)$ is the level energy of state with spin value of I; $S(I)$ is directly proportional to the energy signature splitting. As shown in Fig. 2, the signature inversion is distinct and kept up to the highest spin values observed experimentally.

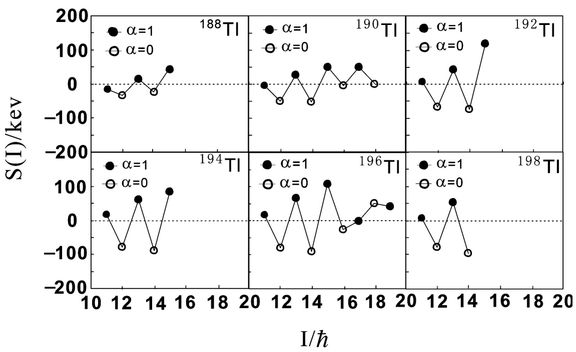

Fig. 2. Signature splitting $S(I)$ as a function of spin I for the $\pi h_{9/2}\otimes\nu i_{13/2}$ oblate band in $^{188-198}$Tl. The filled and open symbols correspond to the favored and unfavored signatures, respectively.

Due to the uncertainties of level spin assignments to the $\pi h_{9/2}\otimes\nu i_{13/2}$bands in doubly odd $^{192-200}$Tl nuclei, Kreiner[7] has proposed two different models to interpret the level energy staggering. The first approach, utilizing a two noninteracting quasiparticle plus rotor model, suggested that the level energy staggering is associated with the signature dependence of the Coriolis interaction. The other one, which is almost identical to the first approach except for the inclusion of a residual proton-neutron (p-n) interaction, attributed the staggering to a J dependence of the p-n residual interaction (J being the total intrinsic angular momentum). These two models produced opposite phases of the staggering[7]. With the spin assignment in the present work, this long-standing problem is now solved. It is the p-n residual interaction that reproduces a correct phase of the staggering observed in the $\pi h_{9/2}\otimes\nu i_{13/2}$ bands in odd-odd Tl nuclei. If a strong repulsive matrix element of the p-n residual interaction acts in the maximally aligned intrinsic state, above the 10^- state a further alignment of the proton and neutron intrinsic spins is energetically more costly and the system prefers to increase its total angular momentum at the expense of collective energy. As a consequence of this, the amplitude of J=11 component in the wave functions for the 11^- and higher states is drastically reduced and meanwhile the role of J=10 component becomes dominant[7]. This leads to the energetically favored states with angular momenta of $I=R+J=R+10$=even and the unfavored states being $I-1=R+10-1$=odd (R=even is the collective angular momentum). Therefore, signature inversion occurs at low spins for these bands.

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扁椭球$\pi h_{9/2}\otimes\nu i_{13/2}$转动带的低自旋旋称反转*

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摘要　利用标准在束γ谱学方法研究了^{188,190}Tl的高自旋态结构, 实验建立了基于扁椭组态$\pi h_{9/2}\otimes\nu i_{13/2}$的强耦合转动带. 重新指定了双奇Tl核中$\pi h_{9/2}\otimes\nu i_{13/2}$扁椭转动带的带头自旋, 从而揭示了这些转动带在低自旋时存在旋称反转. 首次确定了扁椭$\pi h_{9/2}\otimes\nu i_{13/2}$带内存在低自旋旋称反转, 并在粒子–转子模型框架内对该现象进行了解释.

关键词　γ-γ 符合　转动带　旋称反转

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