Search for Signature Inversion in the $\pi i_{13/2} \otimes \nu i_{13/2}$ Bands in ^{182,184,186}Au *

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Abstract Search for low-spin signature inversion in the $\pi i_{13/2} \otimes \nu i_{13/2}$ bands in odd-odd ^{182,184,186}Au has been conducted through the standard in-beam γ-spectroscopy techniques via the ^{152}Sm(^{35}Cl,5n)^{182}Au, ^{172}Yb(^{19}F,5n)^{186}Au, and ^{159}Tb(^{29}Si,4n)^{184}Au reactions, respectively. The $\pi i_{13/2} \otimes \nu i_{13/2}$ bands in these three nuclei have been identified and extended up to high-spin states. In particular, the inter-band connection between the $\pi i_{13/2} \otimes \nu i_{13/2}$ band and the ground-state band in ^{184}Au has been established, leading to a firm spin-and-parity assignment for the $\pi i_{13/2} \otimes \nu i_{13/2}$ band. The low-spin signature inversion is found in the $\pi i_{13/2} \otimes \nu i_{13/2}$ bands according to our spin-assignment and the signature crossing observed at high-spin states.

Key words high-spin states, in-beam γ spectroscopy, signature inversion, odd-odd nuclei

High-spin states in odd-odd nuclei have recently become an important subject of many theoretical[1] and experimental[2] investigations. Most interesting topic currently investigated is the so called low-spin signature inversion which has been widely observed throughout the chart of nuclides in the $\pi g_{9/2} \otimes \nu g_{9/2}$, $\pi h_{11/2} \otimes \nu h_{11/2}$, $\pi h_{11/2} \otimes \nu i_{13/2}$ and $\pi h_{9/2} \otimes \nu i_{13/2}$ configurations. Present work aims at searching for the signature inversion phenomenon in a new configuration, i.e., the $\pi i_{13/2} \otimes \nu i_{13/2}$ coupling. Prior to this work, no high-spin data are available in literature for ^{182}Au. The $\pi i_{13/2} \otimes \nu i_{13/2}$ bands in ^{184}Au and ^{186}Au have been observed[3, 4] but without firm spin-assignment for the energy levels. We concentrated on the observation of signature crossing at high-spin states, which could be regarded as an indirect evidence for the low-spin inversion. Meanwhile, great efforts have been made to establish the inter-band connection in ^{184}Au since its ground state has been determined experimentally to be a 5^+ formed by the $\pi 3/2^-[532](h_{9/2}) \otimes \nu 7/2^-[514]$ configuration[5, 6].

The standard in-beam γ-spectroscopy experiments for ^{182}Au and ^{186}Au were carried out in the Japan Atomic Energy Agency (JAEA) via the

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^{152}Sm(^{35}Cl,5nγ)^{182}Au and ^{172}Yb(^{19}F,5nγ)^{186}Au reactions, respectively. A study of ^{184}Au was performed in the Laboratori Nazionali di Legnaro (LNL), Italy using the ^{159}Tb(^{29}Si,4nγ)^{184}Au reaction. The targets were 1∼2mg/cm^2 thickness with Pb or Au backing in order to avoid the Doppler shift of emitting γ rays. The γ-ray detector arrays GEMINI in JAEA and GASP in LNL were used. Detailed experimental conditions and data analysis will be described later. On the basis of γ-γ coincidence relationships, level schemes of the $\pi i_{13/2}\otimes\nu i_{13/2}$bands in ^{182,184,186}Au have been established and presented in Fig. 1. The level scheme of ^{182}Au is newly established in this work, and the bands in ^{184}Au and ^{186}Au have been extended up to higher- and lower-spin states comparing to the results of previous publications[3, 4].

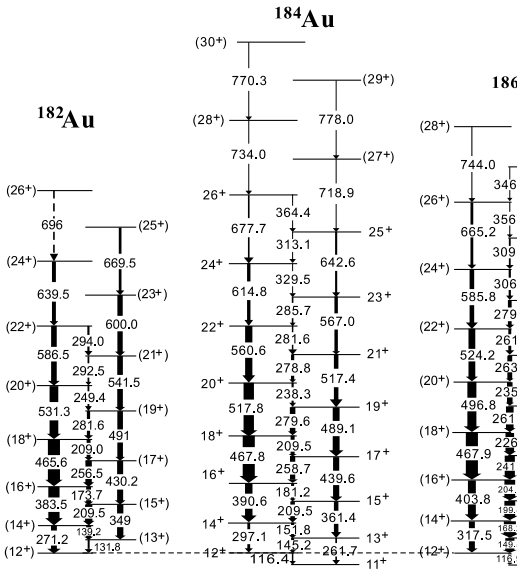

Fig. 1. Level schemes of the $\pi i_{13/2}\otimes\nu i_{13/2}$ bands in ^{182,184,186}Au deduced in this work. Levels are normalized to the 12^+ states and γ-ray intensities to the $18^+\rightarrow16^+$ transitions for each band.

The spectroscopic connection between the $\pi i_{13/2}\otimes\nu i_{13/2}$ excited band and the $\pi 3/2^t[532](h_{9/2})\otimes\nu 7/2^t[514]$ ground-state band in ^{184}Au has been firmly established in this work due to observations of several interband transitions. Consequently, the lowest member of the $\pi i_{13/2}\otimes\nu i_{13/2}$ band can be assigned as 11^+. As the ground-state spins and parities of ^{182}Au and ^{186}Au are unknown, and the $\pi i_{13/2}\otimes\nu i_{13/2}$ bands observed here are floated in energy, their spins and parities indicated in Fig. 1 have been assigned mainly on the basis of the level spacing systematics, quasi-particle alignments, and signature splitting, respectively. The level spins of the $\pi i_{13/2}\otimes\nu i_{13/2}$ band in ^{186}Au are thus increased by one unit comparing to the previous assignment[4].

A plot of signature splitting, defined as $S(I)=E(I)-E(I-1)-1/2[E(I+1)-E(I)+E(I-1)-E(I-2)]$, as a function of level spin I is given in Fig. 2 for the $\pi i_{13/2}\otimes\nu i_{13/2}$ bands in ^{182,184,186}Au. The expected favored signature is $\alpha_{\rm f}(\pi-\nu)=\alpha_{\rm f}(\pi)+\alpha_{\rm f}(\nu)$=1/2+1/2=1 for the $\pi i_{13/2}\otimes\nu i_{13/2}$ configuration. It can be seen in this figure that, it is the unfavored-signature branch (i.e., $\alpha_{\rm u}(\pi-\nu)=\alpha_{\rm f}(\pi)+\alpha_{\rm u}(\nu)$=1/2−1/2=0) that is favored energetically at low and medium spins rather than the $\alpha_{\rm f}(\pi-\nu)$=1 transition sequence. Such a behavior has been referred to as the low-spin signature inversion[7]. With increasing angular momentum, the inverted signature splitting becomes decreasing, and the two signature branches cross with each other at $I_{\rm C}\sim22^+$ beyond which normal signature splitting is observed. The similar staggering pattern shown in Fig. 2 seems to suggest that the low-spin signature inversion occurs in the three $\pi i_{13/2}\otimes\nu i_{13/2}$ bands and the proposed level spins for ^{182,186}Au are reasonable.

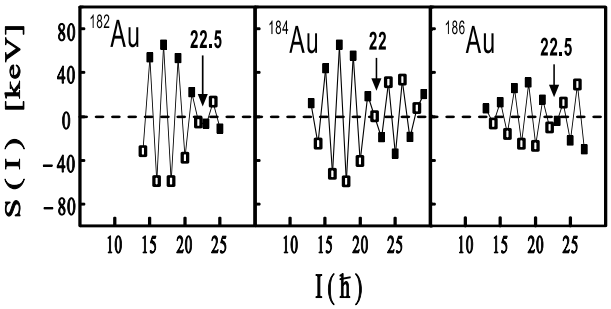

Fig. 2. Signature splitting for the $\pi i_{13/2}\otimes\nu i_{13/2}$ bands in ^{182,184,186}Au. The arrows indicate signature inversion spins.

The low-spin signature inversion in the $\pi i_{13/2}\otimes\nu i_{13/2}$ bands has been investigated in the framework of 2-quasiparticle plus rotor model[8, 9]; it has been determined that the inversion phenomenon is caused by the proton-neutron residual interactions, in which the particle-hole component plays a key role. However the low-spin signature inversion in the $\pi h_{11/2}\otimes\nu h_{11/2}$

bands in the A=130 region has been investigated recently by Gao et al[10] in the framework of a triaxial projected shell model. Without invoking the p-n residual interactions, the signature inversion data in the odd-odd Cs isotopes, not only the signature inversion spins but also the magnitude of signature splitting, have been nicely reproduced by introducing a sizable nuclear triaxial deformation. As for ^{182,184,186}Au, two signature-inversed bands have been observed in each nucleus, and the $\pi i_{13/2}\otimes\nu i_{13/2}$ configuration is very similar to the $\pi h_{11/2}\otimes\nu h_{11/2}$ coupling (i.e. both proton and neutron occupy the same high-j orbit with proton in the Ω=1/2 down-sloping Nilsson orbit), the signature inversion data in ^{182,184,186}Au provide certainly a crucial testing ground for this new physical interpretation.

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在 ^{182,184,186}Au 的 $\pi i_{13/2}\otimes\nu i_{13/2}$ 带中寻找旋称反转*

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摘要 为了搜寻 ^{182}Au, ^{184}Au, ^{186}Au 核中 $\pi i_{13/2}\otimes\nu i_{13/2}$ 转动带的旋称反转, 我们通过 ^{152}Sm(^{35}Cl,5n)^{182}Au, ^{171}Yb(^{19}F,4n)^{186}Au 和 ^{159}Tb(^{29}Si,4n)^{184}Au 反应对^{182}Au, ^{184}Au, ^{186}Au 核进行了在束 γ 谱学研究. 本工作扩展了这 3 个核 $\pi i_{13/2}\otimes\nu i_{13/2}$ 带的能级纲图, 特别是确定了^{184}Au 核 $\pi i_{13/2}\otimes\nu i_{13/2}$ 带的能级自旋宇称, 发现了低自旋旋称反转现象.

关键词 高自旋态 在束 γ 谱学 旋称反转 双奇核

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