High-spin states and signature inversion studies in ^{110}Ag*

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Abstract The high-spin states of ^{110}Ag were populated via fusion evaporation reaction ^{110}Pd(^{7}Li, 2p2n)^{110}Ag and a new level scheme has been presented. The systematics of signature splitting and signature inversion of the $\pi g_{9/2}\otimes\nu h_{11/2}$ configuration band in Ag isotopes are studied. The spin of inversion point decreases with increasing neutron number and this feature is explained as due to the competition between the p-n residual interaction and the Coriolis force.

Key words high spin state, signature splitting, signature inversion

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1 Introduction

Signature inversion in doubly odd nuclei has stimulated considerable efforts both experimentally and theoretically. This phenomenon has been studied systematically in three mass regions at A=80, 130 and 160[1—3], and several mechanisms have been proposed[4—6]. However, it is still not clear which mechanism causes signature inversion in different mass regions and if there exists a universal mechanism or not. Collecting more experimental data in new mass regions could help in answering these questions.

In the present work, the study in ^{110}Ag by in-beam γ-ray spectroscopy method was performed and the limited level scheme is extended. Signature splitting and signature inversion of $\pi g_{9/2}\otimes\nu h_{11/2}$ band in ^{110}Ag have been compared with its isotopes ^{102,104,106,108,112,114,116}Ag[7—12].

2 Experiment and results

The experiment was performed at the HI-13 tandem accelerator in the China Institute of Atomic Energy. The high spin states of ^{110}Ag were populated via heavy-ion fusion evaporation reaction ^{110}Pd(^{7}Li, 2p2n)^{110}Ag at a beam energy of 49 MeV. The target consisted of 2.4 mg/cm^2 Pd backed with 0.4 mg/cm^2 Au. The γ-rays from the evaporated residues were detected with an array consisting of fourteen Compton suppressed HPGe-BGO spectrometers. More than 190×10^6 γ-γ coincidence events were collected.

The recorded γ-γ coincidence data were sorted into a two dimensional $\boldsymbol{E}_\gamma$-$\boldsymbol{E}_\gamma$ symmetry matrix. Background-subtracted coincidence spectrum were generated and shown in Fig. 1. Coincidence relationships extracted from the gated spectra allow for establishing the level scheme of ^{110}Ag. The new level scheme shown in Fig. 2 is the extension of previously

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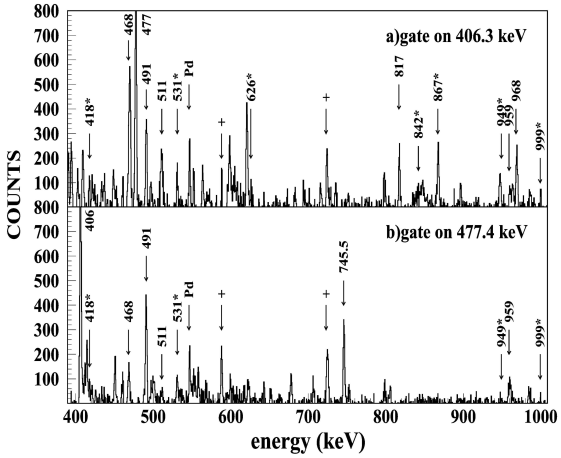

Fig. 1 Sample coincidence spectra showing transitions in ^{110}Ag with gates on the a) 406.3 keV and b) 477.4 keV transitions. The lines marked with a star show new transitions observed in this work. Those marked with a cross show random coincidences with the transitions which come from the main product ^{112}In of the reaction.

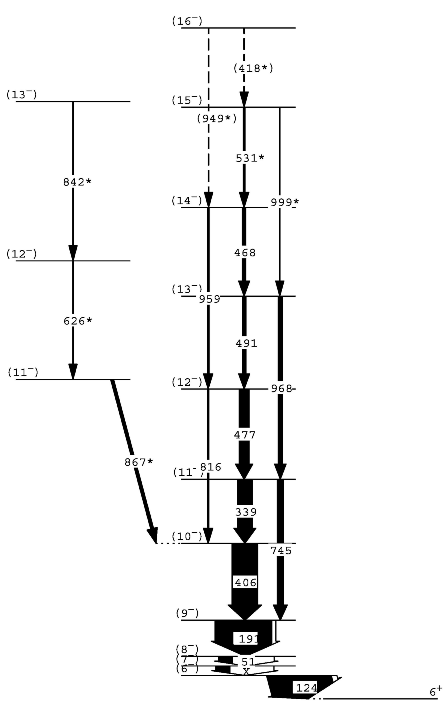

Fig. 2 Partial level scheme of ^{110}Ag. The transitions marked with a star are new transitions observed in this work. The width of each arrow is proportional to the intensity of the transition.

reported data[11]. Several new transitions, viz., the 531, 418, 999, 949, 867, 626 and 842 keV γ rays were placed in the level scheme. The previously known series of intense transitions have been extended in spin from $I^{\pi}=14^{-}$ to $I^{\pi}=16^{-}$. The placements of 418 and 949 keV γ transitions are tentative. A relatively weak set of γ transitions, namely, 867, 626 and 842 keV γ rays that feed the $I^{\pi}=10^{-}$ energy level were placed in the level scheme.

3 Discussion

The yrast states observed in the odd-odd nucleus ^{110}Ag are built on the 6^{-} state and the configuration $\pi g_{9/2}\otimes\nu h_{11/2}$ has been assigned to this band[11]. In many cases, rotational bands in odd-odd nuclei do not display the regular structure, since the excited levels with one signature are shifted relative to the ones with the other signature. The expected favored signature branch lies lower in energy than the unfavored signature branch is called normal signature splitting. However, it can be seen in Fig. 3 that, it is the unfavored signature branch that lies lower in energy at low spin rather than the favored signature branch. Such a behavior has been referred to as signature inversion[6]. This phenomenon has been observed in the $\pi g_{9/2}\otimes\nu h_{11/2}$ bands of Ag isotopes except ^{112,114}Ag for lack of data.

The systematic features can be found by comparing the $\pi g_{9/2}\otimes\nu h_{11/2}$ bands of ^{110}Ag and its isotopes. First, the amplitude of signature splitting doesn't change obviously among Ag isotopes as shown in Fig. 4. Second, the spin of inversion point decreases with increasing neutron number for Ag isotopes as shown in Fig. 3.

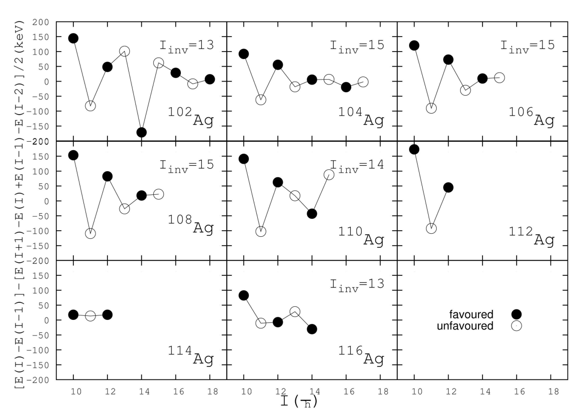

Fig. 3 Signature inversion as a function of spin I in ^{110}Ag and its odd-odd isotopes. The solid circles and open circles indicate favored signature and unfavored signature, respectively.

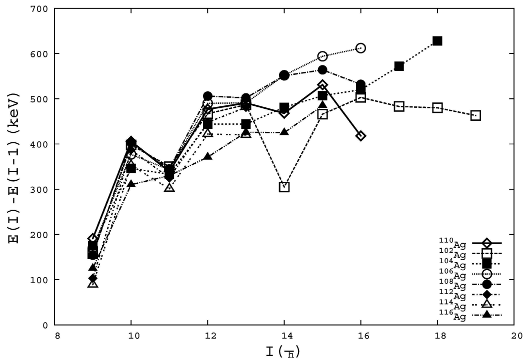

Fig. 4 Signature splitting as a function of spin I in ^{110}Ag and its odd-odd isotopes.

It is worthwhile to find the reason for the systematic behavior for Ag isotopes. One of the explanations is that signature splitting is associated with the Coriolis force, and the amplitude of signature splitting increases with increasing Coriolis force. The proton-neutron residue interaction may be the reason for abnormal splitting, p-n interaction is important to the inversion spin behavior[2].

For the $\pi g_{9/2} \otimes \nu h_{11/2}$ bands of Ag isotopes, proton Fermi surface locates at the top of $g_{9/2}$ shell and neutron Fermi surface locates at the bottom of $h_{11/2}$ shell. Therefore in $A = 100$ mass region neutron occupies small Ω orbital, the angular momentum of valence nucleon is almost parallel with the rotating axis and the Coriolis force is stronger, so the level gap of neutron in the $h_{11/2}$ shell is very large, it is difficult to populate the unfavored state and the signature splitting of this band almost comes from proton in $g_{9/2}$ shell. Therefore the amplitude of signature splitting doesn't change obviously among Ag isotopes.

Considering that the j-Ω structure of the $\pi g_{9/2} \otimes \nu h_{11/2}$ bands in the $A = 100$ region is very similar to that of the $\pi h_{11/2} \otimes \nu i_{13/2}$ bands in the $A = 160$ mass region, we can expect there is a similar behavior of the spin of inversion point. In the $A = 160$ region the inversion spin behavior is explained by the competition between Coriolis force and the proton-neutron interactions[1]. As in $A = 160$ region, similar explanation is suitable for $A = 100$ region. The neutron Fermi level increases with increasing neutron number resulting in increasing of the gaps between neutron Fermi surface and neutron Fermi surface, so neutron-proton interaction decreases. Therefore the spin of signature inversion decreases.

As for ^{102}Ag, the observed large decrease of the inversion spin when moving from ^{104}Ag to ^{102}Ag, however, does not fit to this scenario. It might be caused by a configuration mixing of $\pi g_{9/2} \otimes \nu h_{11/2}$ band when moving toward the $N = 50$ closed shell.

4 Summary

The high-spin states in ^{110}Ag have been studied via fusion evaporation reaction ^{110}Pd(^{7}Li, 2p2n)^{110}Ag by in-beam γ-ray spectroscopy method and a new level scheme has been presented. By comparing signature inversion of $\pi g_{9/2} \otimes \nu h_{11/2}$ band in ^{110}Ag with its isotopes, it is indicated that the signature inversion point shifts to a lower spin with the increasing neutron number. The signature inversion mechanism is explained as due to the competition between Coriolis force and the proton-neutron interactions in the chain of Ag isotopes.

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