New band structures in ^{107}Ag*

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Abstract: High spin states in ^{107}Ag are studied via the ^{100}Mo(^{11}B, 4n)^{107}Ag reaction at an incident beam energy of 60 MeV. Prompt γ-γ coincidence and DCO ratios are measured by the detector arrays in CIAE. The level scheme has been updated and a new negative band belonging to ^{107}Ag is identified. The new negative side band has been constructed and its configuration is tentatively assigned to $\pi g_{9/2}\otimes\nu h_{11/2}(g_{7/2}/d_{5/2})$.

Key words: high spin states, level scheme, routhian, alignment

PACS: 21.10.Hw, 25.70.Jj, 23.20.Lv **DOI:** 10.1088/1674-1137/35/11/005

1 Introduction

Recently, two novel types of bands have been predicted theoretically [1–4], which are called magnetic and chiral bands. In these cases the rotational axis is titled away from the principal axes. Nuclei in the $A\sim$105 mass region with 43$\leqslant Z \leqslant$49 have attracted much attention from nuclear physicists in recent years. In this mass region, the proton Fermi surface lies near the high-Ω $1g_{9/2}$ orbitals and the neutrons are situated close to the low-Ω $g_{7/2}$, $d_{5/2}$, and $h_{11/2}$ orbitals. Under this background, nuclei usually show small deformations ($\varepsilon\sim$0.15) with γ soft [5–8]. Their level structures exhibit some exciting features involving shears bands [9–13] and chiral doublet bands [14–19]. In the Rh/Tc isotopes [14–19], chiral bands based on a $\pi g_{9/2}\otimes\nu h_{11/2}$ configuration have been extensively investigated in the last decade. In particular, Rh isotopes, both in the structure of odd-A [14, 16] and the odd-odd nuclei [15, 16], were found to have chirality. In our recent study, evidence of chirality has been found in Ag isotopes (^{106}Ag [20]), moreover, shears bands have also been reported in this nucleus [21, 22]. ^{106}Ag has the same neutron number as ^{104}Rh which has been considered as the center of chirality to occur in Rh isotopes. To understand the evolution of nuclear structures with increasing proton and neutron number, systematic information on isotopes in this mass region is required. Therefore it is very interesting to investigate the high spin structures in ^{107}Ag. The ^{107}Ag nucleus has been investigated before using ^{14}N+^{96}Zr [23], ^{17}O+^{94}Zr [24] and ^{11}B+^{100}Mo [25] reaction for the spectroscopic study. In previous publications [24, 25], 3 rotational band structures were well constructed with some negative parity states decaying by very weak γ transitions. The purpose of this study is to enrich the information on the high

Received 4 January 2011
* Supported by National Basic Research Development Program (2007CB815000) and National Natural Science Foundation of China (10927507, 10975191, 10675171, 11175259)
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spin structures in ^{107}Ag. In this paper we will report on the latest experimental results of ^{107}Ag, and the discussion for the configuration assignment of the newly constructed band.

2 Experiment and results

High spin states in ^{107}Ag were populated through the ^{100}Mo (^{11}B, 4n) reaction at a beam energy of 60 MeV. The target consisted of a 1.56 mg/cm^2 foil of ^{100}Mo (isotopically enriched to 97.4%) on a 8.03 mg/cm^2 natural lead backing. The ^{11}B beam was delivered by a HI-13 tandem accelerator from the China Institute of Atomic Energy (CIAE). The γ-rays were detected by 10 Compton-suppressed HPGe detectors, two low-energy photon (LEP) detectors and one clover detector. The Ge detectors in the array were placed at 90°, ±37°, ±30° and ±60° relative to the beam direction respectively. Each detector had an energy resolution of about 2 keV for 1332.5 keV γ rays. Energy and efficiency calibrations of the detectors were performed using standard sources ^{60}Co and ^{152}Eu. A lower threshold of 90 keV was set for these HPGe detectors to eliminate contamination from K-x rays of lead in the γ-spectra. Coincidence data have been recorded in event-by-event mode when at least two signals from HPGe detectors were generated in 200 ns. A total of 230×10^6 γ-γ coincidence events were recorded. The data were sorted into a fully symmetrized E_γ-E_γ coincidence matrix, as well as into an asymmetric DCO (Directional Correlation ratios of Oriented states) matrix. The DCO matrix was created by arranging the detectors at ±37° on one axis and at ∼90° on the other axis. These matrices were analyzed with the Radware Programs [26].

In this work, the new transitions are placed with coincidence with the known transitions [24, 25]. Based on the γ-γ coincidence relations, together with the intensity balance of transitions and energy matching, the level scheme of ^{107}Ag is finally obtained, as presented in Fig. 1. The spin and parity are assigned in light of the measured DCO ratio analysis [27] and systematic comparison with its neighboring odd-A nuclei [28, 29]. The majority of transitions of ^{107}Ag observed in the previous work [24] have been confirmed, and 6 new states with 17 new γ transitions are identified as belonging to ^{107}Ag in the present experiment. Band 4 is a newly constructed band. It comprises all the transitions assigned to the band labeled 4 in Ref. [24]. Though the γ transitions with

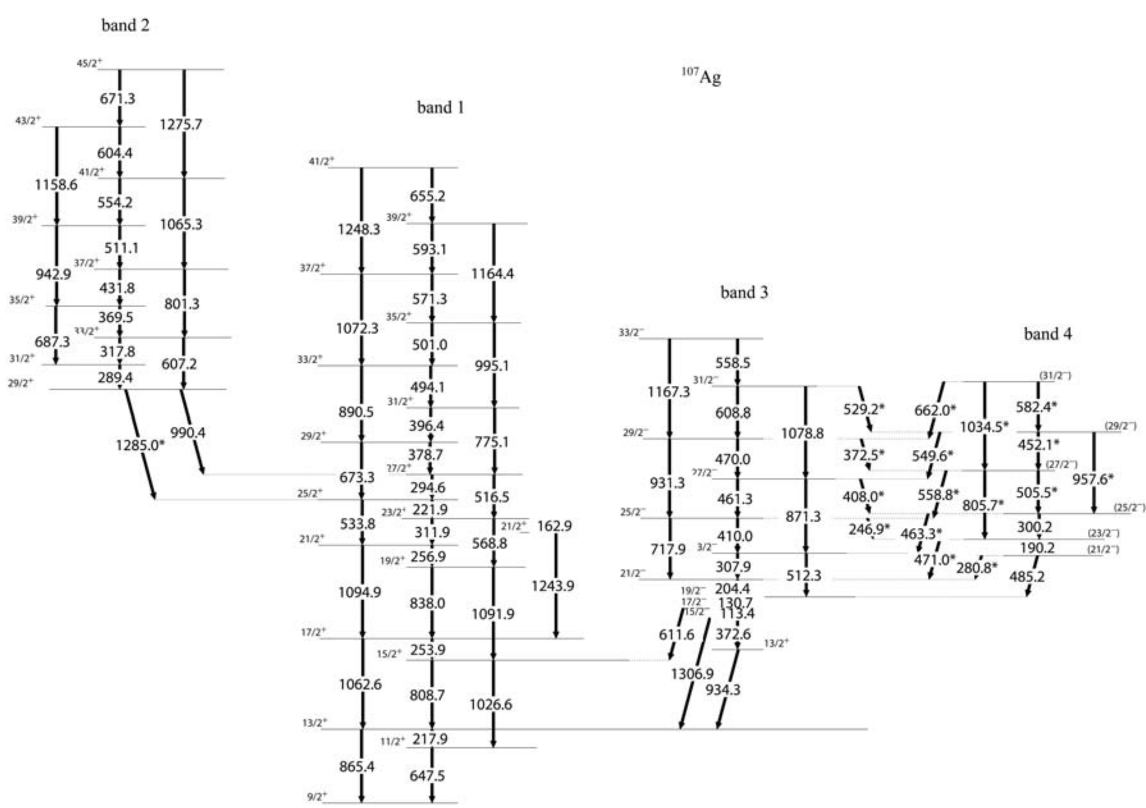

Fig. 1. Level scheme of ^{107}Ag deduced from the present experiment. The energies of the γ transitions and of the levels are given in keV. Spins and parities in parentheses are assigned tentatively. New γ transitions are indicated by asterisks.

energies of 485.2, 190.2 and 300.2 keV have been reported in a previous publication [24], their construction doesn't have arotational structure. In our experiment, their decay sequences are reordered as a rotational band with the observation of new crossover E2 transitions shown in Fig. 1.

Figure 2 presents the sample spectra gated by 505.5, 452.1 and 582.4 keV transitions to show the γ-γ coincidence relations in band 4 of ^{107}Ag. The new set of γ-transitions consisting of 505.5, 452.1, 582.4, 805.7, 957.6, 1034.5 keV, etc. can be seen in Fig. 2. Furthermore the known γ transitions with energies 113.4, 130.7, 190.2, 204.4, 300.2, 307.9, 372.6, 485.2, and 865.4 keV, etc. could also be observed in the corresponding gated spectrum in Fig. 2. On the other hand, one can also get the information of the logic of construction for band 4. For example the 1034.5 keV transition could only be observed in the coincidence spectrum gated by the 505.5 keV transition but not in 452.1 and 582.4 keV, therefore it was placed in parallel positions 452.1 and 582.4 keV. In the same way, the 806.5 and 957.6 keV transitions were placed in band 4. In addition, the 461.3, 410.0, 307.9 keV transitions could be observed separately in the coincidence spectrum gated on the 582.4, 452.1 and 505.5 keV transitions. This proves the existence of inter-band transitions (i.e. 463.3, 549.6, 558.8 keV transitions etc), although they were too weak to be easily indentified.

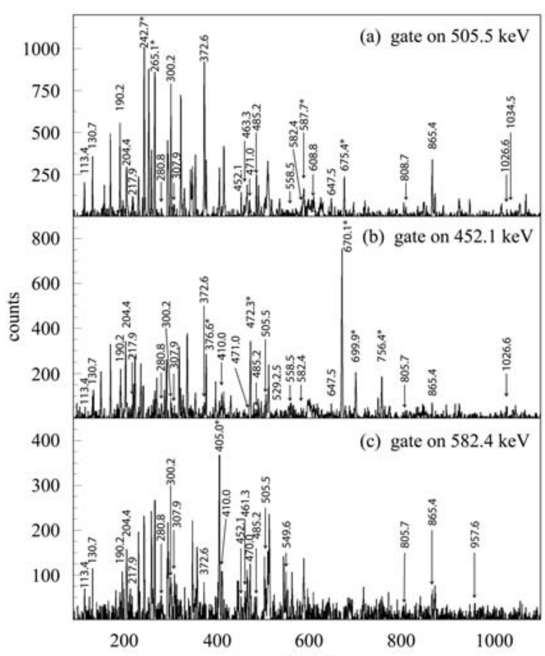

Fig. 2. Examples of the gated coincidence spectra on (a) 505.5 keV, (b) 452.1 keV and (c) 582.4 keV transitions. Peaks labeled with their energy in keV are assigned to ^{107}Ag. Peaks marked with asterisks are contaminations from ^{100}Mo (^{11}B, 5n) ^{106}Ag, ^{100}Mo (^{11}B, 1p3n) ^{107}Pd and ^{208}Pb (^{11}B, 4n) ^{215}Fr reaction channels.

3 Discussion

In the present experiment band 1 and 2 were assigned positive parity and band 3 was assigned negative parity. They were previously reported in Refs. [24, 25], their configurations were also explicitly discussed in these publications. Band 4 is new to the present experiment. It was assigned negative parity based on pervious results [24]. We will now discuss the rotational structure of band 4. To discuss the configurations of the newly observed band, the experimental Routhians e' and alignments i_x, shown in Fig. 3 and Fig. 4 as a function of rotational frequency ($\hbar\omega$), were calculated according to the standard procedure described in previous papers [30–32], with the Harris parametrization of the moment of inertia: $J_0 = 8.9\hbar^2$ MeV^{-1} and $J_1 = 15.7\hbar^4$ MeV^{-3} taken from previous work [29].

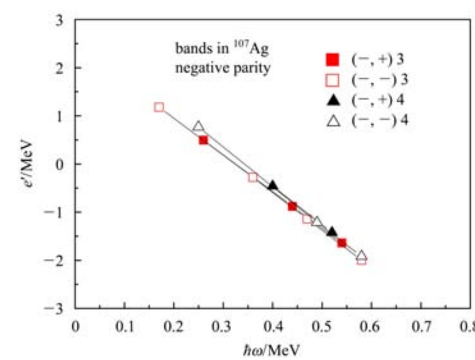

Fig. 3. Experimental quasiparticle Routhians for band 3 and 4 of ^{107}Ag. (−, +) indicates negative parity and a positive signature, while (−, −) denotes negative parity and a negative signature.

It is obvious in Fig. 2 that the M1 transitions in band 4 are much stronger than the E2 transitions. It indicates that band 4 is a magnetic dipole band with no signature splitting ($\Delta e'$ [30] $\sim$0), as shown in Fig. 3. From the Nilsson diagrams one can deduce that for a silver nucleus with a slightly prolate deformation, the last odd proton will be occupying an orbital with K equal to 7/2 $\hbar$, which is because silver is three particles away from the Z=50 shell, thus filling the $\pi g_{9/2}$ Nilsson orbital with seven protons. On the basis of the 1$g_{9/2}$ proton configuration, the neutron configuration may partly come from the lowest quasiparticle orbital $h_{11/2}$. This configuration

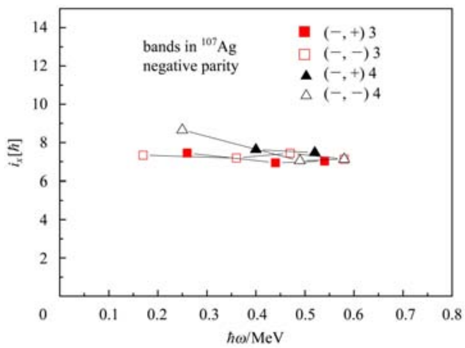

Fig. 4. Experimental quasiparticle alignments for band 3 and 4 of ^{107}Ag. (−, +) indicates negative parity and a positive signature, while (−, −) denotes negative parity and a negative signature.

provides a possible explanation for the large magnetic moment in band 4. On the other hand, band 4 presents the experimental aligned angular momentum i_x of about $8\hbar$ in Fig. 4. But the high Ω $g_{9/2}$ orbital proton contributes very little [24]. For the configuration of neutrons, $1g_{7/2}$, $2d_{5/2}$ and $1h_{11/2}$ orbitals lie near the Fermi surface. One neutron excited from the $1g_{7/2}$ or $2d_{5/2}$ orbital to $1h_{11/2}$ orbital apropos completes the demand of aligned angular momentum and the negative parity. The positive parity orbitals from $(g_{7/2}, d_{5/2})$ are close in excitation energy. Therefore, the configuration for band 4 is tentatively suggested as $\pi g_{9/2} \otimes \nu h_{11/2}(g_{7/2}, d_{5/2})$. This configuration has also been assigned to band 3 in a previous publication [24]. Fig. 3 and 4 show that they have semblable experimental Routhians and alignments. Similar band structures have been observed in ^{105}Ag [28] too. In Ref. [28], TRS calculations suggested that the configurations of these two bands in ^{105}Ag have the same neutron from the $1h_{11/2}$ orbital and proton from the $1g_{9/2}$ orbital, but for the other neutron from $1g_{7/2}$ or $2d_{5/2}$ orbitals, they have different signatures. By comparing with ^{105}Ag, the neutron from the $1g_{7/2}$ or $2d_{5/2}$ orbitals in band 3 of ^{107}Ag may have a positive signature, whereas in band 4 it has a negative signature.

Band 3 and 4 in ^{107}Ag constitute a near degenerate doublet structure, and they have nearly the same alignments. Similar structures have been interpreted as possible chiral bands in its isotopic nuclei [28] and neighboring nuclei [14, 16]. Band 3 and 4, therefore, could also be a solution to chiral bands. But more quantitative indicators are the B(E2) and B(M1) values for chirality. They will be obtained to give further experimental evidence through lifetime measurement in the next body of work.

4 Summary

In summary, the high spin states of ^{107}Ag were populated by a ^{100}Mo (^{11}B, $4n$) ^{107}Ag reaction. The level scheme has been updated and a new negative band belonging to ^{107}Ag is identified. The configuration for band 4 is briefly discussed. The negative band 3 and 4 constitute a doublet bands structure, but further analysis is required to understand their nature.

The authors are grateful to the crew of HI-13 tandem accelerator in the China Institute of Atomic Energy for steady operation of the accelerator and to Dr. Q. W. Fan for preparing the target.

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