Structure of high spin states in ^{112}In*

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Abstract The high spin states of ^{112}In have been populated via the ^{110}Pd(^{7}Li, 5n)^{112}In reaction with a beam energy of 50 MeV. By analyzing the γ-γ coincidence relations and DCO ratios of γ transitions，A new level scheme of ^{112}In including seventy-four new gamma transitions and six new bands up to the excitation energy of 6.8 MeV has been presented.

Key words high spin state, in-beam γ-ray spectroscopy, level scheme, rotational band

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1 Introduction

In recent years, high-spin states in odd-odd nuclei have become an important subject of many theoretical and experimental investigations in $A \sim 100$ mass region, there exists plenty of information of nuclear structure, for example, shape co-existence, band termination, magnetic rotations, triaxial deformation and so on[1, 2]. Most interesting topic currently investigated is the magnetic rotation in weakly deformed nuclei and chiral rotation of triaxial nuclei. Experimentally, magnetic rotation bands have been identified in many nuclei such as ^{105,106,108}Sn[3, 4], ^{108}Sb[5], ^{108,110,111,113}In[6—8] in the $A \sim 100$ mass region with the suggested configuration $\pi g_{9/2}^{-1} \otimes \nu h_{11/2}$. Up to now, the level structure and information on ^{112}In is very few[9, 10], the doubly odd nucleus ^{112}In is selected as the object to investigate magnetic and chiral rotation bands in the present work.

2 Experimental details

High spin states of ^{112}In were populated using the ^{110}Pd(^{7}Li,^{5}n)^{112}In reaction at HI-13 Tandem accelerator of China Institute of Atomic Energy，and studied by in-beam spectroscopic technique with a detector array comparising 14 BGO Compton-suppressed HPGe detectors. In the $\gamma - \gamma$ coinci-

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dence experiment these HPGe detectors were at angles 90°,37°,27°,30.5°, and 120.5° to the beam axis, respectively. The target consisted of a 2.4 mg/cm^2 thick ^{110}Pd enriched to 97.2(±0.1)% and a Au backing with thickness of 0.4 mg/cm^2. The $\gamma-\gamma$ coincidence data was collected at a beam energy of 50 MeV, accumulated $1.9\times10^8\gamma-\gamma$ coincidence events. The energy and efficiency calibrations of the HPGe detectors were done using radioactive sources ^{152}Eu.

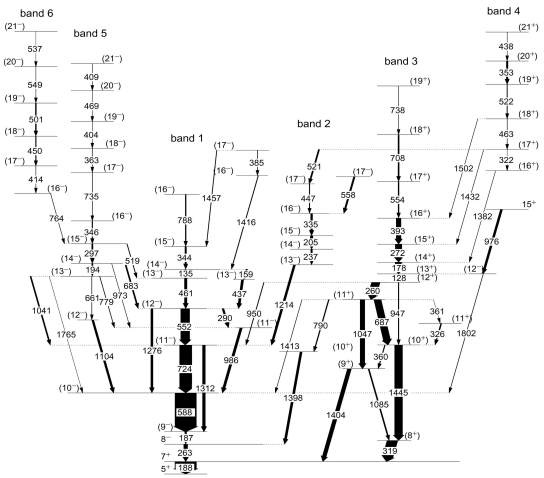

Fig. 1. The level scheme of ^{112}In from the present experiment. Transition energies are marked in keV. The 188, 263, 187, 319 keV are known γ transitions.

3 Results and discussion

In 1976, the excited states of the odd-odd nucleus ^{112}In were populated by means of the reaction ^{110}Pd(^{6}Li,4n)^{112}In by M.Eibert, et.al[9], two negative parity bands were constructed and the spin was pushed to 10$\hbar$. In 1988, the γ-ray spectra of the ^{112}Cd(p,n)^{112}In and ^{109}Ag(α,n)^{112}In reactions were measured with Ge(Li) spectrometers for bombarding energies of 4.8 MeV protons and 17.1 MeV α particles by T.Kibedi, et al[10]. The 188 keV $7^+\rightarrow5^+$ transition was confirmed according to the experimental g factor of the level compared to the theoretical result.

In the present work, the γ-γ coincidence data were sorted offline into conventional $\boldsymbol{E}_\gamma$-$\boldsymbol{E}_\gamma$ matrices and asymmetry DCO matrices. The background-corrected projected spectra generated with gates on the gamma transitions were used to construct the level scheme. These matrices were analyzed by using the RADWARE[11] package based on a Linux-PC system. By analyzing the γ-γ coincidence relations, the level scheme of ^{112}In including to 74 new γ transitions based on the scheme by T.Kibedi were added(Fig.1).

In analysis of the γ spectrum, there are other reaction products, including ^{113}In,^{112}Cd,^{111}In,^{109}Ag, and so on. The ratio of DCO of the γ transitions was calibrated using known γ multipolarity of ^{112}Cd[12]. In measurement of γ-γ coincidence performed by using the multidetectors situated at 90° and 30°(include 150°) relative to the beam direction, respectively, the DCO ratio is defined as

$$R_{\rm DCO}=\frac{I_0(90°,30°)}{I_0(30°,90°)}.$$

Where I_γ90°,30°) means the observed intensity of γ_1 at 90° gated by γ_2 at 30°, in like manner, I_γ(30°, 90°) means the observed intensity of γ_1 at 30° gated by γ_2 at 90°. The gating transition γ_2 has either a pure dipole or quadrupole multipolarity. When the gate is set on the quadrupole transition the $R_{\rm dco}$ value was close to 1.0 for $\triangle I=2$ transition and close to 0.6 for $\triangle I=1$ transition. Similarly, for a dipole gating transition, the $R_{\rm dco}$ values was close 1.5 for quadtrpole (Fig. 2) transition. The measured DCO ratios and multipolarities of the γ transitions in ^{112}In are listed in Table 1.

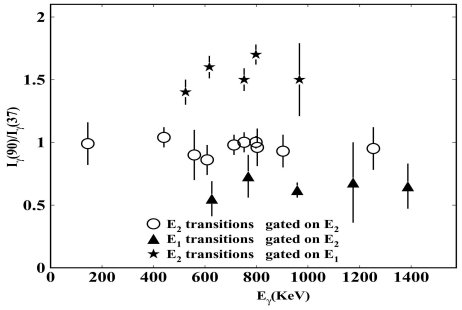

Fig. 2. Ratio $I_\gamma(90°)/I_\gamma(37°)$ of the transition intensities in ^{112} Cd.

4 Conclusions

The high spin states of ^{112}In have been populated via the ^{110}Pd(^{7}Li,5n)^{112}In reaction. By analyzing the γ-γ coincidence relations and DCO ratios, a new level scheme of ^{112}In including seventy-four new gamma transitions and six new bands have been established up to 6.8 MeV in excitation energy and to a tentative spin of (21$^+$).

a)Energy error is less than 0.5 keV; b)Relative intensities normalized to 100 for the 588 keV($10^-\rightarrow9^-$) transition; c)DCO ratios from gating on pure dipole

transition; d)DCO ratio from gating on quadrupole transition.

Table 1. Energies, relative intensities, DCO ratios, and multipolarities of transitions assigned to ^{112}In in the present experiment.

$E_\gamma^{a)}$/keV	$I_\gamma^{b)}$	$R_{dco}^{d\ c)}$	$R_{dco}^{e\ d)}$	multi-polarity	$I_i^\pi \to I_f^\pi$
128	4.73(5)	1.12(6)		(M1)	$13^+ \to 12^+$
178	4.48(4)	1.1(7)		(M1)	$14^+ \to 13^+$
260	3.38(16)	1.0(5)		(M1)	$12^+ \to 11^+$
272	4.53(4)	1.0(8)		(M1)	$15^+ \to 14^+$
319	3.23(20)		0.41(16)	(M1)	$8^+ \to 7^+$
393	4.49(13)	0.93(10)		(M1)	$16^+ \to 15^+$
554	1.00(32)	0.86(7)		(M1)	$17^+ \to 16^+$
687	2.29(14)	0.94(7)		(M1)	$11^+ \to 10^+$
708	0.7(7)	0.86(15)		(M1)	$18^+ \to 17^+$
738	0.76(10)	0.93(20)		(M1)	$19^+ \to 18^+$
947	1.09(3)	1.2(10)		(E2)	$12^+ \to 10^+$
1047	0.92(20)	1.7(16)		(E2)	$11^+ \to 9^+$
1085	0.41(24)	0.8(8)	1.6(3)	(M1)	$9^+ \to 8^+$
1404	1.35(17)	0.9(20)		(E2)	$9^+ \to 7^+$
1445	2.25(30)	1.4(10)	0.92(17)	(E2)	$10^+ \to 8^+$

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