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Shears bands in ^{112}In*

LI Xue-Qin(李雪琴)[1,6;1)] ZHU Li-Hua(竺礼华)[5;2)] WU Xiao-Guang(吴晓光)[1] HE Chuang-Ye(贺创业)[1] LIU Ying(刘颖)[1] PAN Bo(潘波)[1] HAO Xin(郝昕)[1] LI Li-Hua(李立华)[1] WANG Zhi-Min(王治民)[1] LI Guang-Sheng(李广生)[1] LI Zhong-Yu(李忠宇)[2] WANG Shou-Yu(王守宇)[2] XU Qiang(徐强)[3] WANG Jian-Guo(王建国)[3] DING Huai-Bo(丁怀博)[3] ZHAI Jian(翟建)[4]

1 (China Institute of Atomic Energy, Beijing 102413, China)
2 (Peking University, Beijing 100871, China)
3 (Tsinghua University, Beijing 100084, China)
4 (Jilin University, Changchun 130023, China)
5 (Shenzhen University, Shenzhen 518060, China)
6 (National Institute for Radiological Protection, Chinese Center for Disease Control and Prevention, Beijing 100088, China)

Abstract A new level scheme of ^{112}In have been established up to 6.8 MeV in excitation energy and to a tentative spin of (21^+) through the reaction ^{110}Pd(^{7}Li, 5n)^{112}In at a beam energy of 50 MeV. In-beam measurements involving γ-γ coincidences and directional correlation of oriented states were performed. M1 bands consisting of $\triangle I=1$ dipole transitions have been observed. Possible quasiparticle configurations suggest that these bands are similar to the shears bands observed in Pb nuclei.

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

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1 Introduction

Recently, most interesting topic currently investigated is the magnetic rotation in weakly deformed nuclei in $A\sim100$ mass region. Experiments in this mass region have resulted in a wealth of data for the shears bands in several isotopes of $^{104,108-110}$Cd[1—4], ^{105,106,108}Sn[5, 6], ^{108}Sb[7], ^{108,110,111,113}In[8—10]. Within the titled axis cranking approach which takes into account the rotational perturbation effects on the high-K band correctly, angular momentum in high-K bands is generated due to collective rotation as well as shearing of the high-j particle and hole angular momenta. The important feature that emerges as the high-K $\pi g_{9/2}^{-1}$ bands, is that this configuration evolves progressively into a well-deformed configuration (reflected in the $B(\mathrm{M1})/B(\mathrm{E2})$ values); at low deformations, the shears mechanism dominates to generate angular momentum for such configurations[10]. In this work, we report the observation of band consisting of magnetic dipole transitions. The dipole bands have similarities with the recently observed shears bands in singly closed shell nuclei.

2 Experimental details

High spin states in ^{112}In were populated using the reaction ^{110}Pd(^{7}Li, 5n)^{112}In 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. The target consisted of a 2.4 mg/cm^2 thick ^{110}Pd enriched to 97.2(±0.1)% and a Au backing which thickness of 0.4 mg/cm^2. This reaction was chosen because of its large cross section for the production of ^{112}In between

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1) E-mail: lixq@ciae.ac.cn

2) E-mail: zhulh@ciae.ac.cn

40 MeV to 50 MeV, with relatively little competition from other channels. The γ-γ coincidence data was collected at a beam energy of 50 MeV, accumulated 1.9×10^{8} γ-γ coincidence events. The energy an efficiency calibrations of the HPGe detectors were done using radioactive sources ^{152}Eu. The γ-γ coincidence data were sorted offline by gain matching each of the detectors using the ^{152}Eu data. The subtracted projected spectra generated with gates on the ^{112}In gamma transitions were used to construct the level scheme.

3 Results and discussion

The level scheme deduced from the present experiment is shown in Fig. 1. In this paper the band 3 is discussed. The set of γ transitions consisting of 128, 178, 260, 272, 393, 319, 360, 554, 687, 708, 738 keV et al constitute band 3. The regular structure found in ^{112}In is very similar to regular $\triangle I = 1$ bands observed in the In isotopes ^{108,110,111,113}In[8—10] as well as in the neutron-deficient lead isotopes ^{198,199,200}Pb[11—13]. Common features for a majority of these $\triangle I = 1$ bands are as follows: (i) very strong $\triangle I = 1$ transitions leading to $B(\mathrm{M1})/B(\mathrm{E2})$ ratios of about 20 $\mu_{\mathrm{N}}^2/e^2b^2$; (ii) low values for $J^{(2)} = \mathrm{d}I/\mathrm{d}\omega$, the dynamic moment of inertia, except at band crossing (illustrated for ^{112}In in Fig. 2.); (iii) no signature splitting in the regular bands (Fig. 3. signature in ^{112}In band 3); (iv) The angular momentum is dominated by aligned quasi-particles.

The ratio $B(\mathrm{M1})/B(\mathrm{E2})$ was expression

$$\frac{B(\mathrm{M1},I\rightarrow I-1)}{B(\mathrm{E2},I\rightarrow I-2)} = 0.697\times\frac{E_\gamma(I\rightarrow I-2)}{E_\gamma(I\rightarrow I-1)}\times \frac{1}{\lambda}\times\frac{1}{1+\delta^2}\mu_{\mathrm{N}}^2/e^2b^2 \ .$$

With $\lambda =$ branching ratio $I_\gamma(\triangle I=2)/I_\gamma(\triangle I=1)$. The mixing ratio δ could not be determined accurately from the DCO ratio results. We have assumed $\delta^2 \ll 1$ because the measured mixing ratios are also small in the $A=130$ region[15] and for ^{199,200}Pb[13].

Therefore, the calculated values of $B(\mathrm{M1})/B(\mathrm{E2})$ represent an upper limit, the result is $B(\mathrm{M1})/B(\mathrm{E2}) \sim 260\mu_{\mathrm{N}}^2/e^2b^2$ of the 12^+ state, and there is no E2 transition above the 12^+ state. The band 3 is up to state with (21^+). The dominant feature in band 3 is the sequence of transitions do

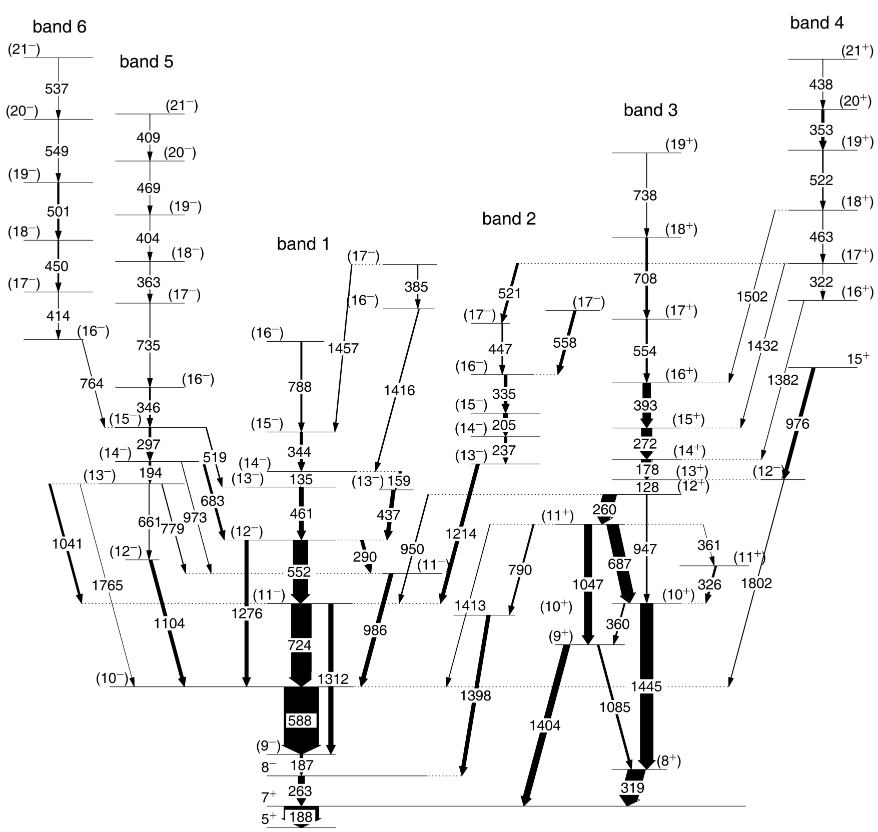

Fig. 1. The level scheme of ^{112}In from the present experiment. Transition energies are marked in keV. The 188, 263, 187, 319 keV are known γ transitions.

not extend to high spins and are characterized by large $B(\mathrm{M1})/B(\mathrm{E2})$ ratios. These two facts indicate that the intrinsic structure of band 3 is not a well-deformed nucleus. It is to be mentioned that in the $A\sim200$ mass region, rotational-like sequences of levels have been observed that are connected by unusually strong M1 transitions having almost no E2 strength. The titled axis cranking calculations suggest that in these bands the spins of the valence protons align along the symmetry axis, while the spins of the valence neutrons align along the axis of rotation. With increasing spin, these two components tilt towards each other, while the direction of the total spin remains unchanged[14]. Such structures are expected to appear in the Sn region and more generally in nuclei closed shells[15], due to the interaction of high-j particle and hole configurations of protons and neutrons.

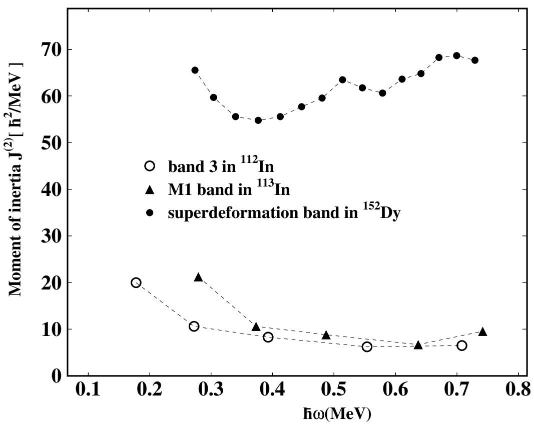

Fig. 2. The dynamic moment of inertia $J^{(2)}$ in ^{112}In band 3, ^{113}In[10] M1 and in ^{152}Dy[16] of superdeformed band.

In ^{112}In, for states above 3 MeV it is expected that quasiparticle excitations become important. The lowest band crossing in this mass region is due to alignment of $h_{11/2}$ neutrons. Potential energy surface calculations predict a small prolate deformation ($\beta=0.105$, $\gamma=-120°$) for this configuration. At such low deformations, the neutrons occupy the low-Ω states of the $h_{11/2}$ orbital. A shear mechanism is one possibility to account for the positive parity states. Hence, band 3 may possibly involve a configuration of aligned ($h_{11/2}$) neutrons in low-Ω orbitals coupled to a $\pi g_{9/2}$ hole.

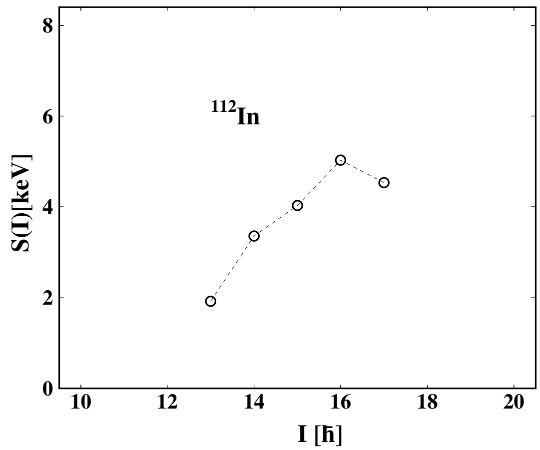

Fig. 3. The signature in ^{112}In band 3(K=12).

4 Conclusions

High spin state have been investigated in ^{112}In. Band 3 consisting of predominantly magnetic dipole transitions have been observed. Within the tilted axis cranking approach, angular momentum in high-K bands is generated due to collective rotation as well as shearing of the high-j particle and hole angular momenta. The fraction of angular momentum shared between these two modes depends on deformation . The important feature that emerges as one studies the high-K prolate $\pi g_{9/2}^{-1}$ bands, is that at low deformations, such as in In nuclei, the shears mechanism dominates to generate angular momentum for such configurations.

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