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High-spin states in the vibrational nucleus ^{114}Cd

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Abstract. High-spin states of the neutron-rich vibrational nucleus ^{114}Cd have been studied using the incomplete fusion reaction ^{110}Pd(^{7}Li, p2n) and the GASP spectrometer in conjunction with the ISIS Si ball. About 50 new states with excitation energies up to 7 MeV and angular momentum $I \leq (18^{+})$ were observed and for many of them, spin and parity could be firmly assigned. The band-like stuctures in ^{114}Cd are compared to the corresponding ones in the even-even neighbour ^{112}Cd.

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1 Introduction

The even-mass Cd isotopes near the middle of the $N = 50$–82 neutron shell are among the textbook examples of quadrupole vibrational nuclei. In addition to collective vibrational excitations, rotational bands built on two-particle two-hole proton excitations across the $Z = 50$ shell closure have been observed in this region. Whereas the midshell isotope ^{114}Cd has extensively been studied at low spin using a variety of different techniques such as inelastic scattering, transfer and neutron capture reactions, the available information on high-spin states in this nucleus is scarce. This is mainly because it cannot be produced in heavy-ion–induced fusion-evaporation reactions. Whereas in ^{112}Cd states with spins as high as 14^{+} are known from (α, 2n) reactions [1], ^{114}Cd cannot even be reached using this reaction and the only information about its high-spin structure comes from recent studies using fusion-fission reactions and heavy-ion collisions [2–4].

It is very interesting to gain more information about the heavier isotopes ^{112,114}Cd at high spin because in the lighter even isotopes $^{104-110}$Cd, a number of rotational bands involving the deformation-driving low-K $h_{11/2}$ neutron orbitals have been observed. The interplay between these neutron intruder and vibrational excitations in the midshell isotope ^{114}Cd is particularly interesting because it is expected that the $h_{11/2}$ orbit plays a much more dominant role, even at low spin, in ^{114}Cd than in the lighter isotopes. Since the $h_{11/2}$ intruder orbit is close to the Fermi surface already at the spherical shape, the intruder bands might be less deformed leading possibly to a stronger mixing with the vibrational excitations in ^{114}Cd.

2 Experiment and results

^{7}Li-induced incomplete-fusion reactions have been proven to be a powerful tool to study neutron-rich nuclei up to relatively high spin (see, *e.g.*, [5]). Here, the reaction $^{7}\mathrm{Li} + {}^{110}\mathrm{Pd}$ has been used to populate ^{114}Cd. In a first step, the yields of the different reaction products have been determined at three different beam energies of 32 MeV, 35 MeV and 40 MeV and then, the beam energy of 35 MeV has been chosen for the production run as the best compromise between cross-section for the population of ^{114}Cd as p2n channel, on the one hand, and the average entry spin on the other. The γ-rays have been detected with the GASP spectrometer at the Laboratori Nazionali di Legnaro and the ISIS Si ball was used to detect the charged particles at the low beam energy used mainly protons and deuterons. In the top part of fig. 1, the total projection of the unconditioned γ-γ matrix obtained in the present experiment is shown. Clearly, the by far strongest reaction channel at 35 MeV beam energy is

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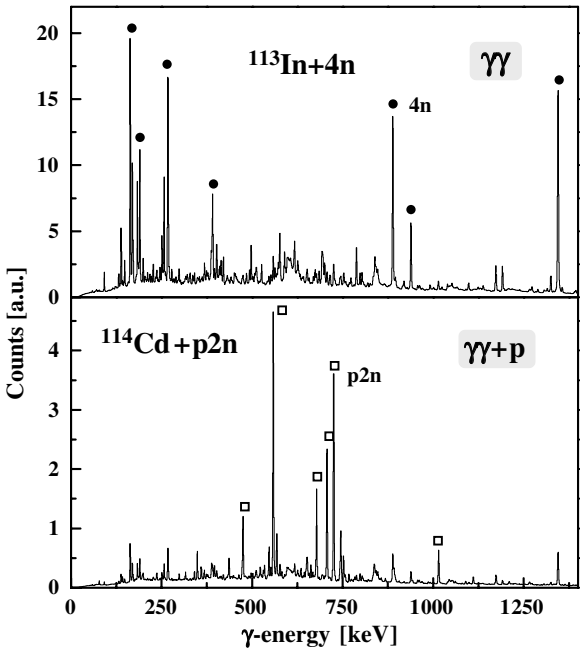

Fig. 1. Projections of the total (top) and the proton-gated γ-γ matrix (bottom) from the reaction ^{7}Li + ^{110}Pd at 35 MeV.

the 4n channel leading to ^{113}In. However, the strongest known γ-lines belonging to ^{114}Cd are already visible in this total projection. In comparison, the projection of the γ-γ matrix constructed in coincidence with a proton detected in ISIS is shown in the bottom part of fig. 1. Nearly all strong lines in this spectrum belong to the nucleus of interest, ^{114}Cd. The extension of the known level scheme of this nucleus was based on the analysis of this proton-gated γ-γ matrix. Altogether about 50 new excited states could be established in ^{114}Cd with excitation energies up to 7 MeV and in the spin range up to (18^{+}). For many of them, we were able to firmly assign spin and parity on the basis of the ratio between the γ-ray intensities observed at 35°/145° and 90° with respect to the beam direction. The new information constitutes a considerable extension of our knowledge of this nucleus. In fig. 2, the excitation energies are plotted as function of the spin for the members of the positive-parity yrast bands in ^{112}Cd and ^{114}Cd. In both nuclei, a band crossing is observed and from spin 10^{+} on, the rotational band built on the $\nu(h_{11/2})^2$ two-particle configuration forms the yrast line. The newly established quasi-γ band in ^{114}Cd is compared to the corresponding known band in ^{112}Cd in fig. 2, too. In ^{114}Cd, only the 2^{+}, 3^{+}, and 4^{+} members of this band were known prior to this work. Now, this sequence could be extended up to spin (17^{+}). In both nuclei, this band exhibits a large signature splitting at low spin, typical for this type of band. From fig. 2, a close similarity between ^{112}Cd and ^{114}Cd can be concluded and this analogy is also observed for other bands like the proton intruder band and the negative-parity yrast band not discussed in the present contribution. The full account of our results obtained from the present experiment will be presented in a forthcoming publication [6].

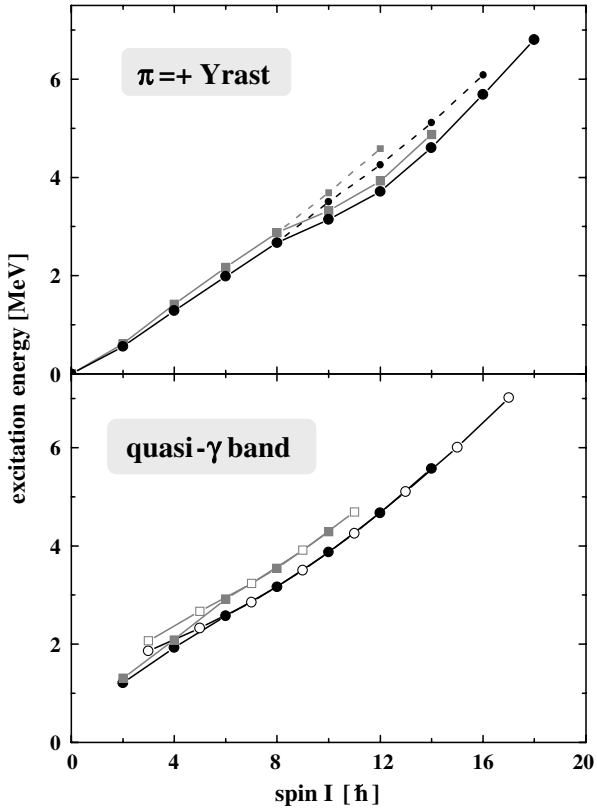

Fig. 2. Excitation energy *vs.* spin plots for the positive-parity yrast bands (top) and the quasi-γ bands (bottom) in ^{112}Cd (grey squares) and ^{114}Cd (black circles). Filled and open symbols mark states of the two different signatures.

3 Conclusion

It has been demonstrated that new information about the high-spin structure of the neutron-rich midshell Cd isotope ^{114}Cd can be obtained employing incomplete-fusion reactions induced by a ^{7}Li beam. We were able to identify about 50 new excited states with spin values as high as (18^{+}).

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