ENERGY LEVELS IN ^{114,116,118,120,122}Cd POPULATED IN THE DECAY OF Ag ISOTOPES

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Abstract

The decays of Ag isotopes to even Cd isotopes with $114 \leq A \leq 122$ have been investigated. The following levels are populated (energies in keV): ^{114}Ag → ^{114}Cd ($T_{1/2} < 10$ s): 558 (2^+), 1134 (0^+). ^{116}Ag → ^{116}Cd ($T_{1/2}$ = = 3 min): 513.5 (2^+), 1154.0 (0^+), 1212.8 (2^+), 1922. ^{116}Ag → ^{116}Cd ($T_{1/2}$ = 10 s): 513.5 (2^+), 1219 (4^+), 2026. ^{118}Ag → ^{118}Cd ($T_{1/2}$ = = 4.5 s): 487.1 (2^+), 1165, 1269 (2^+). ^{120}Ag → ^{120}Cd ($T_{1/2}$ = 1.3 s): : 505.5 (2^+), 1203, 1324 (2^+). ^{122}Ag → ^{122}Cd (short): 569 (2^+) (tentative).

1. Introduction

The even Cd nuclei with mass-number ≤ 114 have been extensively studied [1], and some data exist also on ^{116}Cd [2,3]. The lowest excited states in these nuclei are generally interpreted in terms of quadrupole vibrations of a spherical nucleus. However, neutron-rich nuclei with Z around 44 are expected to be deformed [4,5]. From this point of view it is of interest to investigate Cd nuclei around mass-number 120, which can be expected to be on the border between this deformed region and the spherical region around Z = 50.

The present paper is a preliminary report of a study of the levels in ^{118}Cd and ^{120}Cd from the decay of ^{118}Ag and ^{120}Ag. In addition we have studied the little known decays of ^{114}Ag → ^{114}Cd and ^{116}Ag → → ^{116}Cd. Tentative evidence was also found for the first excited state in ^{122}Cd.

2. Experiment

The Ag activities were produced as fission products and mass-separated in the OSIRIS facility [6] at Studsvik. In this arrangement a

uranium target is placed within the ion-source of the mass-separator close to the reactor core. The fission products are thermalized in graphite, which has a temperature of about 1500°C, thereby allowing the products to diffuse and evaporate rapidly After mass-separation the fission products of the selected mass-number were collected on a movable aluminium tape for rapid transportation to a position 11 cm away from the ion beam, where the measurements were made. Gamma-ray spectra were measured with a 30 cc Ge(Li)-detector connected to a Nuclear Data 3300 4k analyzer. By varying the time of collection and measurement spectra associated with different half-lives were enhanced. The element(s) associated with each half-life was determined from similar measurements of X-rays and conversion electrons using Si(Li)-detectors. For ^{116}Cd and ^{120}Cd gamma-gamma coincidence measurements were performed with 25 cc and 30 cc Ge(Li) coaxial detectors using the digital gate system of the ND 3300 analyzer.

3. Results

The measurements are not yet complete, and in this paper only some preliminary results will be given. Table 1 gives the energies and intensities of the strongest gamma-rays in each of the decays studied. For ^{122}Cd only a tentative assignment of one gamma-ray could be made. This was based on the observation of a half-life of the gamma-ray, which is shorter than that of the decay of ^{122}In → ^{122}Sn, and the energy, which is too large to be likely to be a transition in ^{122}In but fits into the systematics of $2^+ \rightarrow 0^+$ transitions in even Cd nuclei. Tentative level schemes deduced from the strongest transitions are shown in fig. 1. In ^{114}Cd the two strongest transitions 558 and 576 keV were identified also in the (n,γ) reaction [7]. Several additional transitions in ^{114}Cd were found, which have to await a coincidence experiment to be localized.

The energy of the strongest transition in ^{116}Cd agrees well with the energy of the first excited state earlier observed [2,3] in ^{116}Cd. The remaining part of the level scheme of fig. 1 rests mainly on observed coincidence relationships. The two different half-lives found for ^{116}Ag were found mainly to feed different levels in ^{116}Cd. The assignment of the 1213 keV state as 2^+ is based on the fact that a cross-over to the

ground state was found and that no 1^+ or 1^- state has been observed in this energy region in lighter Cd isotopes. The tentative 4^+ assignment of the 1219 keV level is based on the earlier observation of a close doublet of 2^+ and 4^+ states at ~1220 keV [2]. The tentative 0^+ assignment of the 1154 keV state is also based on systematics [1,2].

For ^{118}Cd no coincidence measurements have been made so far. The 487 and 1165 keV levels are based on the fact that the 487 and 678 keV transitions are the strongest and second strongest transitions observed. The 1269 keV 2^+ state is based on the energy-fit of the transitions involved and the systematic occurrence of 2^+ states in even Cd nuclei. The 129 keV transition observed to follow the 4.5 s decay was found to convert in Ag, implying an isomeric level in ^{118}Ag. The fact that we observed no gamma-rays following a half-life different from 4.5 s implies that the ground state in ^{118}Ag either has $T_{1/2} \ll 4.5$ sec or that it not at all or only very weakly feeds excited states in ^{118}Cd.

The levels in ^{120}Cd are based mainly on coincidence relationships. The arguments for the 2^+ assignment of the 1324 keV state are the same as for the corresponding states in the other Cd nuclei.

As mentioned above the observation of the first excited state in ^{122}Cd is very tentative.

4. Comments

The lowest part of the level schemes of ^{116,118,120}Cd look very similar to the lighter Cd nuclei [1] and give no evidence of any rotational structure. In table 2 we give the ratio of the reduced E2 transition probabilities from the second excited 2^+ state. This is expected to be small (0) for a vibrational nucleus, while it is large for a rotational nucleus (0.70 for a pure K=2 state). We see that this ratio although it raises a factor of 3 in going from ^{114}Cd to ^{120}Cd still is fairly small, both for ^{118}Cd and ^{120}Cd. This indicates that the exitation mechanism in even Cd nuclei is essentially unaltered when the neutron number changes.

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Table 1.

Energies and intensities of transitions in even Cd isotopes populated in the decay of Ag isotopes

Decay	Gamma-ray energy keV [a]	Gamma-ray intensity [b]
$^{114}Ag \rightarrow {}^{114}Cd$ (< 10 s)	558.27 [c]	100
	575.93 [c]	8.8
	597	4.8
$^{116}Ag \rightarrow {}^{116}Cd$ (10 s)	513.5	100
	666.2	4.0
	699.7	14.5
	705.3	36.5
	806.8	6.5
	1029.8	14.0
	1213.2	6.3
$^{116}Ag \rightarrow {}^{116}Cd$ (3 min)	513.5	100
	640.5	3.4
	699 7	13
	835	4.7
	1213.2	7.6
$^{118}Ag \rightarrow {}^{118}Cd$ (4.5 s)	487.1	100
	677.9	43
	770.6	5.5
	781.8	5.5
	797.8	7.9
	1060.0	7.5
	1269.7	3.1
$^{120}Ag \rightarrow {}^{120}Cd$ (1.3 s)	203.2	13.2
	505.5	100
	697.6	43
	818.4	15
	1323.5	10.8

a) The uncertainty is estimated to $\pm$ 1 keV

b) Normalized to 100 for the strongest transition in each decay. The uncertainty is estimated to $\pm$ 20 % for all values

c) From ref. [7]

Table 2.

The ratio of the reduced E2 transition probabilities from the second 2^+ state in even Cd nuclei.

A	$\frac{B(E2;\ 2^{+\prime} \rightarrow 0^+)}{B(E2;\ 2^{+\prime} \rightarrow 2^+)}$ a)
114	0.018
116	0.028
118	0.050
120	0.065

a) Assuming the $2^+ \rightarrow 2^+$ transition to be pure E2. The Uncertainty can be estimated to about 25 %.

References

1) C M Lederer, J M Hollander and I Perlman, Table of Isotopes, J Wiley and Sons, New York 1967.

2) F K McGowan, R L Robinson, P H Stelson and J L C Ford, Jr., Nucl. Phys. 66 (1965) 97.

3) J A Cookson and W Darcey, Nucl. Phys. 62 (1965) 326.

4) S A E Johansson, Arkiv Fysik 36 (1967) 599.

5) S G Nilsson and I Ragnarsson, private communication.

6) S Borg, I Bergström, G B Holm, B Rydberg, L E DeGeer, G Rudstam, B Grapengiesser, E Lund and L Westgaard, To be published.

7) A Bäcklin, N E Holmberg and G Bäckström, Nucl. Phys. 80 (1966) 154.

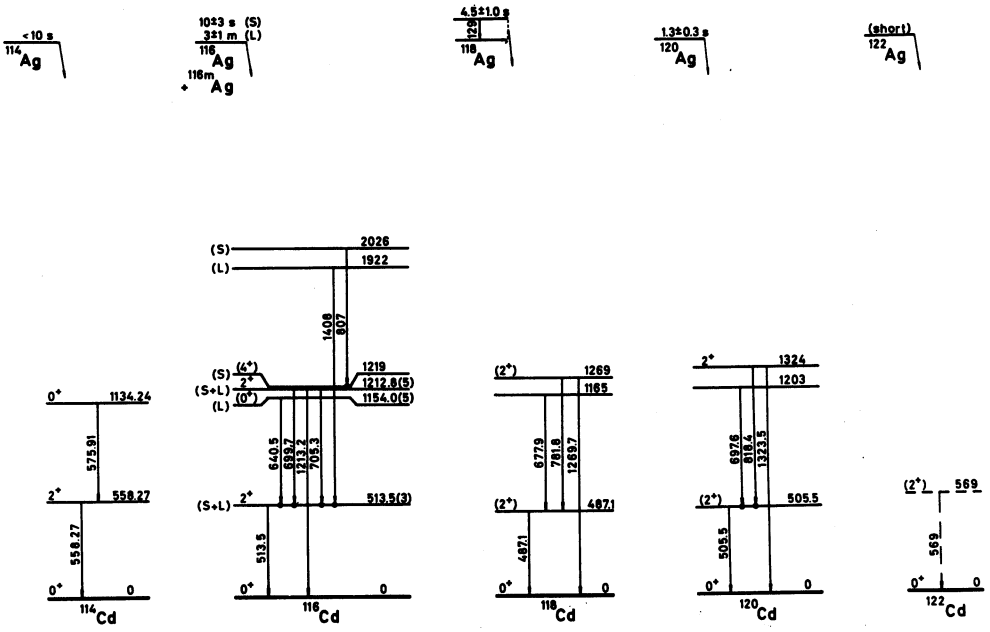

Figure 1. Preliminary level schemes of even Cd isotopes as populated in the decay of Ag isotopes. Energy errors are given in parentheses. When no error is given the uncertainty is ± 1 keV. The energies in ^{114}Cd are taken from ref. [7].