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Structure of neutron-rich even-even ^{124,126}Cd

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Abstract. New levels are reported for ^{124,126}Cd populated in the decay of ^{124,126}Ag isomers, respectively. In addition, new data from direct population of levels in ^{124}Cd from alpha-induced fission of ^{238}U are reported, along with new shell-model calculations for ^{126}Cd.

PACS. 23.40.-s β decay; double β decay; electron and muon capture – 21.10.-k Properties of nuclei; nuclear energy levels – 21.60.-n Nuclear structure models and methods

Owing to the importance of the structure and decay of ^{130}Cd for r-process nucleosynthesis calculations, we have pursued the study of the structure of lighter even-even Cd nuclides [1]. In particular, we reported new 2^+ and 4^+ energies for ^{124,126,128}Cd that included the unexpected downturn for these energies in ^{128}Cd relative to ^{126}Cd [2]. In this paper, additional data for the structure of ^{124}Cd and ^{126}Cd are reported, both from study of Ag decay [3] and from direct population of ^{124}Cd levels in alpha-induced fission of ^{238}U [4].

The decay studies were performed at ISOLDE where neutron-rich Ag isotopes were ionized using the Resonance Ionization Laser Ion Source (RILIS) and isolated with the on-line mass separator. There is a strong synergy between experimental data from radioactive decay and experimental data from studies of high-spin states in nuclear reactions performed with large γ-ray arrays. In radioactive decay, identification of the origin of γ-rays is determined by the mass separator following chemically selective ionization. Moreover, as the laser can be turned off, mistaken identity can be avoided. In contrast, data taken with large γ-ray detector arrays, such as Gammasphere, are taken non-selectively with respect to the nucleus of origin. However, the use of triple-coincidence data analysis methods prove to be quite selective if two or more members of the yrast cascade in any product nuclide can be identified. The alpha-induced fission data used in this study were taken with Gammasphere and sorted into triple-coincidence cubes with broad mass gates. For these data, the mass gate was set for $110 \leq A \leq 130$.

A new partial level scheme for ^{124}Cd is shown in fig. 1. The intensity values shown are from the decay of the particular mixture of isomers obtained in these experiments at ISOLDE. As can be seen, the 613 keV level is populated far more strongly than any of the other levels, indicating population in the decay of a low-spin ^{124}Ag isomer, with J probably ≥ 2. Two yrast cascades were identified in the double gates set in the α-induced fission data that are indicated by circles in fig. 1, one from the 2936 keV level tentatively identified as the 10^+ yrast level, and another from the 7^- level at 2384 keV. As these data suggest that the 10^+ level is populated indirectly, in the decay of the higher-spin ^{124}Ag isomer, it is likely that the spin of the high spin isomer is 7 or greater.

A new partial level scheme for ^{126}Cd is shown in fig. 2. The yields for ^{126}Ag that can be obtained at ISOLDE drop by about a factor of 10 for each additional neutron in the parent nuclide, hence far fewer data are available for analysis than were available for ^{124}Ag decay. In particular, no second 2^+ level has been identified that decays to both the ground and first-excited state in a manner similar to the 1428 keV level in ^{124}Cd. As the first 2^+ level at

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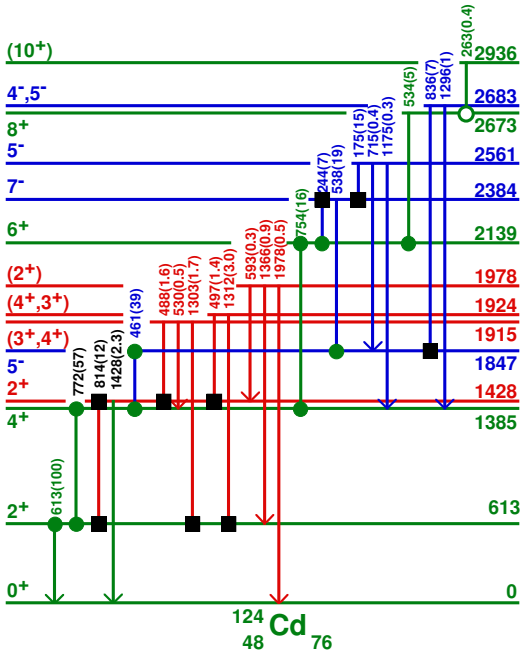

Fig. 1. Level scheme for ^{124}Cd. The round filled dots indicate the observation of the coincidence in both ^{124}Ag decay and in fission, the filled squares indicate coincidences observed only in the decay data, and the open circle, a coincidence observed only in the fission data.

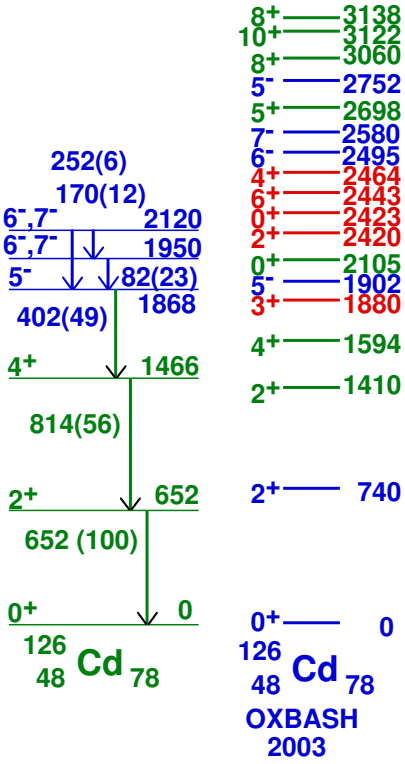

Fig. 2. Observed and calculated levels for ^{126}Cd.

613 keV is populated much more strongly than other levels, it must be assumed that there are also two isomers in ^{126}Ag undergoing β^- decay. Another interesting feature of the level scheme is the near equality for the intensities of the 814 keV 4^+ to 2^+ transition and the 402 keV 5^- to 4^+ transition. This near equality suggests that there is little population of higher-spin positive-parity 6^+, 8^+, and 10^+ levels that cascade directly to the 1466 keV 4^+ level as was observed for the decay of the high-spin isomer in ^{124}Ag.

In a recent study of radioactive decay and isomeric decay performed at the NSCL using the β-counting system and the SEGA array, decay of an isomeric state was identified in ^{126}Cd [5]. The cascade from the 5^- level at 1868 keV was quite strongly populated along with a number of additional γ-rays not observed in ^{126}Ag decay. Owing to a low-energy γ-ray background in the NSCL data, γ-rays below 200 keV were not observed, hence, it was not possible to determine whether the 82 and 170 keV γ-rays were a part of the isomeric decay observed in that experiment. As had been done for ^{124}Cd, a double gate was set on the 652 and 814 keV γ-rays in the fission data set. No additional γ-rays were observed, indicating that most of the population of ^{126}Cd in fission is to the isomeric level or levels.

The structure of ^{126}Cd that is calculated using the shell-model code OXBASH is shown in fig. 2. These calculations used the same parameter set as used for the ^{130}Cd calculations reported by Dillmann *et al.* [1], except that it was necessary to truncate the calculation by including the deep $f_{5/2}$ proton hole as a part of the core. Both full and truncated calculations were performed for ^{128}Cd. For the full calculation, the energies of most of the positive-parity levels (including the 10^+ level) were from 100 to 200 keV higher than for the truncated calculation. In contrast, the second 2^+ and the negative-parity 5^- and 7^- levels were at about the same positions in both calculations. Thus, it might be expected that a full calculation for ^{126}Cd would place most of the positive-parity levels slightly above the positions found in the truncated calculation and shown in fig. 2.

Recently, Scherillo *et al.*, reported an experimental and theoretical study of structures of neutron-rich In and Cd nuclides [6]. These authors, who did not observe an isomerism in ^{126}Cd, presented a calculated level structure for ^{126}Cd that was further truncated by neglecting contributions from the neutrons. Hence, their calculated 2^+ and 4^+ energies of 950 and 1784 keV, respectively, are far above the calculated levels we show in fig. 2.

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