LIFETIME DETERMINATION
OF EXCITED STATES IN $^{106}$Cd

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(Received November 11, 2006)

Two separate experiments using the Differential Decay Curve Method have been performed to extract mean lifetimes of excited states in $^{106}$Cd. The medium-spin states of interest were populated by the $^{98}$Mo($^{12}$C, 4n) $^{106}$Cd reaction performed at the Wright Nuclear Structure Lab., Yale University. From this experiment, two isomeric state mean lifetimes have been deduced. The low-lying states were populated by the $^{96}$Mo($^{13}$C, 3n)$^{106}$Cd reaction performed at the Institut für Kernphysik, Universität zu Köln. The mean lifetime of the $I^\pi = 2^+_1$ state was deduced, tentatively, as 16.4(9) ps. This value differs from the previously accepted literature value from Coulomb excitation of 10.43(9) ps.

PACS numbers: 21.10.Tg, 23.20.Lv, 25.70.Gh, 27.60.+j

* Presented at the Zakopane Conference on Nuclear Physics, September 4–10, 2006, Zakopane, Poland.
1. Introduction

In terms of low-lying excitations, the cadmium nuclei are considered some of the best examples of quasi-vibrational nuclei (see reference [1] and references therein). However, from the systematics of the $B(E2)$ values of the $I^\pi = 2^+_1 \to 0^+_1$ and $I^\pi = 4^+_1 \to 2^+_1$ transitions in $^{104-110}$Cd [2], the $B(E2)$ values in $^{106}$Cd appear to be larger than the systematic trend of the light cadmium isotopes, whose $B(E2)$ values decrease, approaching $^{102}$Cd [3]. Within the medium-spin regime, it is evident that there are collective structures with occupation of at least one $\nu h_{11/2}$ orbital [4].

This paper summarises two experiments using the Recoil Distance Method (RDM) and Differential Decay Curve Method to determine $B(E2)$ values for various transitions in $^{106}$Cd.

2. Experimental details

2.1. DDCM experiment of the medium-spin states in $^{106}$Cd

For population and analysis of the medium-spin states in $^{106}$Cd, an experiment was performed at the Wright Nuclear Structure Laboratory, using the New Yale Plunger Device [5] and SPEEDY $\gamma$-ray array [6] consisting of seven HPGe clover detectors, four at $41.5^\circ$ and three at $138.5^\circ$, with both angles relative to the beam axis. The $^{98}$Mo($^{12}$C, 4n)$^{106}$Cd reaction channel was utilised, with $E^{(12)}C_{\text{LAB}} = 60$ MeV. Further details of the experiment can be found in [7].

2.2. Lifetime determination of isomeric states in $^{106}$Cd

The deduction of the $I^\pi = 9^-$ and $8^-$ isomeric state lifetimes was performed using the 330$\mu$m and 2008$\mu$m target-stopper distances from the Yale experiment. The lifetime of the $I^\pi = 9^-$ state at $E_x = 3678$ keV in $^{106}$Cd was deduced by gating on the shifted component of the 646 keV, $I^\pi = 11^- \to 9^-$ transition and projecting, fitting, deconvoluting and normalising the stopped and shifted components of the 269 keV, $I^\pi = 9^- \to 7^-$ transition, as detailed in [8]. The deduced mean lifetime, $\tau$, of the $I^\pi = 9^-$ state at $E_x = 3678$ keV is 0.89(20) ns.

A similar procedure was performed for the mean lifetime of the $I^\pi = 8^-$ state at $E_x = 3507$ keV in $^{106}$Cd by gating on the shifted component of the 598 keV, $I^\pi = 10^- \to 8^-$ transition and projecting, fitting, deconvoluting and normalising the stopped and shifted peaks of the 188 keV, $I^\pi = 8^- \to 6^-$ transition. The deduced mean lifetime of the $I^\pi = 8^-$ state at $E_x = 3507$ keV is 1.7(5) ns.

2.3. DDCM experiment of the low-spin states in $^{106}$Cd

A second experiment was performed at the Institut für Kernphysik, Universität zu Köln, which utilised the Köln plunger and the $^{96}$Mo($^{13}$C, 3n)$^{106}$Cd reaction at $E^{(13)}C_{\text{LAB}} = 43$ MeV. In this experiment, twenty distances
were measured, eight of which (6 µm, 8 µm, 13 µm, 16 µm, 18 µm, 21 µm, 25 µm and 37 µm) are used in the preliminary analysis presented here. The reaction γ rays were detected using seven individual segments of one germanium cluster detector (one segment was at an angle of 0° and the other six segments were at an angle of 34.5° relative to the beam axis) and five additional single crystal germanium detectors, each at an angle of 141.5° relative to the beam axis.

For both experiments, prompt coincidences were sorted into angle-dependent γ–γ matrices and were analysed with the TV matrix viewer [9]. The lifetimes were deduced by using the Differential Decay Curve Method (DDCM) [10].

2.4. Preliminary analysis of the $I^\pi = 2^+_1$ state lifetime

From the Köln experiment, three separate 1 keV wide energy coincidence gates were placed on the backward shifted component of the 861 keV, $I^\pi = 4^+_1 \rightarrow 2^+_1$ transition. Projecting, fitting, deconvoluting and normalising the stopped and backward shifted components of the 633 keV, $I^\pi = 2^+_1 \rightarrow 0^+_1$ transition.
transition yields mean lifetimes of 15.5(14) ps, 16.7(16) ps (see Fig. 1) and 
17.4(19) ps. The weighted mean of these values yielded a mean lifetime of 
the $I^\pi = 2^+_1$ state of 16.4(9) ps.

3. Discussion and conclusion

For the isomeric states, the $I^\pi = 9^-$ and $I^\pi = 8^-$ mean lifetimes of 
0.89(20) ns and 1.7(5) ns compare well to the previously reported values of 
1.0(+2,-4) ns and 1.7(6) ns deduced by the “centroid shift method” [11]. For 
the $I^\pi = 2^+_1$ state, the mean lifetime of 16.4(9) ps, presented here, differs 
from the literature value of 10.43(9) ps deduced from Coulomb excitation 
[2].

S.F.A. would like to acknowledge financial support from EPSRC DTG 
studentship. Work supported in part by the US DOE under grant nos 
DE-FG02-91ER-40609 and DE-FG02-88ER-40417. P.H.R. would like to ac-
knowledge financial support from EPSRC and the Yale University Flint and 
Science Development Funds. J.J. and A.L. would like to acknowledge finan-
cial support from the Deutsche Forschungsgemeinschaft.

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