The β-decay of $^{129}Cd_{81}$

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Using a combination of the RILIS (Resonance Ionization Laser Ion Source), the HRS (High Resolution Separator) and a neutron-converter system at the PS-Booster ISOLDE to achieve highest possible isobaric selectivity, we have measured β-decay properties of the very neutron-rich cadmium isotopes $^{126\text{-}131}$Cd. Within these investigations we were able to perform first β- and γ-spectroscopic studies of the neutron-magic classical r-process "waiting-point" $^{130}Cd_{82}$ [1]. Its neighbour isotope $^{129}Cd_{81}$ is of less astrophysical importance, but gains considerable nuclear-structure interest. For example, the $\pi g_{9/2}/\pi p_{1/2}$ isomerism is observed in odd-mass indium isotopes from N=56 ^{105}In to N=80 ^{129}In, and likewise valuable information about the development of the $\pi p_{1/2}$, $\pi p_{3/2}$ and $\pi f_{5/2}$ proton-hole states towards the N=82 shell closure can be obtained.

Our measurements have been carried out with a 1 GeV proton beam hitting a Ta neutron-converter close to the UC_x-C target. The ejected reaction neutrons from the converter induce fission in the target instead of spallations when using protons. These fission products are extracted and ionized via RILIS, mass separated with the HRS and then transported to the beamlines.

For time-dependent γ-ray singles and γγ-coincidences, up to four high-efficiency HPGe detectors have been positioned around the collection spot of our Moving Tape Collector. For βγ-spectroscopy, the position face-on to the beam direction was used for a ΔE-E β-telescope.

Since the measurement of the ground-state half-life for ^{129}Cd in 1986 [2], no further experiments were done to identify more β-decay properties. In 2003, Genevey et al. [3] have published four γ-lines belonging to excited states in ^{129}In, including an 8.5 µs isomer. This collaboration used thermal neutron induced fission of ^{241}Pu at the mass separator LOHENGRIN and therefore predominantly observed the de-excitation of high-spin states. These four transitions (334, 359, 995 and 1354 keV) can be confirmed by our data, together with more than 20 new transitions (see Table 1).

As outlined by Arndt [4], the β-decay of ^{129}Cd occurs from the $\nu h_{11/2}$ ground-state ($T_{1/2}$= 242 ms) and the $\nu d_{3/2}$ isomeric state ($T_{1/2}$= 108 ms). The sequence of these ν-orbitals close to ^{132}Sn is not yet clear. Whereas the Nilsson model (with the Bengtsson-Ragnarsson parametrization) places the $\nu d_{3/2}$ level above the $\nu h_{11/2}$, the Folded-Yukawa potential predicts the inverse sequence. Likewise, the so far existing experimental data [5] do not indicate unambiguously, if and where a crossing of the two ν-orbitals occurs when approaching the shell closure at N=82. However, both will populate different excited states in the Gamow-Teller β-decay, leading to the well-known $\pi g_{9/2}$ ground-state and the $\pi p_{1/2}$ isomeric state in ^{129}In. The position of this isomer is only estimated from old Q_β-measurements to lie 380 ±70 keV above the ground-state [6]. Due to the high number of transitions and their partly uncertain coincidence relationships, the construction of a decay scheme is rather complicated and not yet finished. In addition, we have measured time fractions after implantation at the detection position ("time-slices"), and thus decay half-lives of single γ-peaks (see Fig. 1). In this report, we present first results from time-slices and γ-singles spectra.

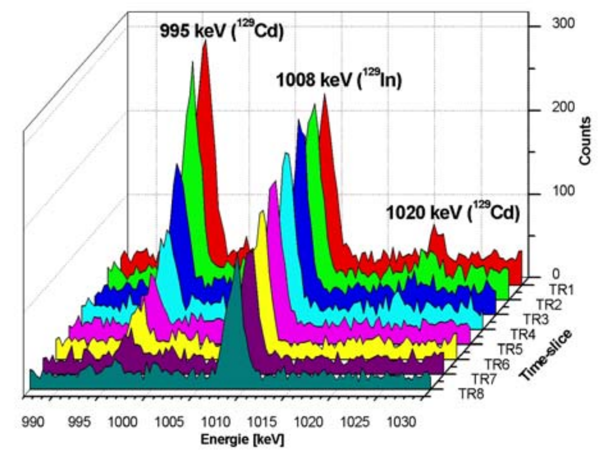

Fig. 1: 90 ms-timeslices of the energy region around 1000 keV in γ-ray singles spectra, showing different half-lives for the 995 keV peak (^{129}Cd: 135 ms) and for the 1008 keV peak (^{129}In: 610 ms).

Table 1: Gamma-lines and relative γ-intensities assigned to ^{129}Cd β-decay. In the column "comment" the half-lives deduced from time-slices are listed. The 334 keV transition may be a doublet, consisting of a stronger part (a), which is the observed 8.5 µs isomer [3], and a weaker part (b).

E_γ [keV]	$I_{\gamma,rel}$ [%]	Comment
333,9 (4)[a]		a: *(strong)* 8.5 µs-isomer;
333,9 (4)[b]	Σ 17,5 (8)	b: *(weak)*; $T_{1/2}$(a+b)= 243 ms
359,1 (4)	45,2 (24)	γγ 995,2 keV; $T_{1/2}$= 136 ms
400,8 (3)	5,9 (6)	
440,2 (4)	4,1 (7)	
537,8 (2)	5,0 (3)	
542,2 (3)	16,5 (32)	$T_{1/2}$= 225 ms
562,1 (4)	7,4 (10)	$T_{1/2}$= 143 ms
632,1 (4)	23,9 (23)	$T_{1/2}$= 148 ms
731,6 (5)	6,6 (10)	doublet ^{129}In
840,2 (6)	7,8 (21)	
995,2 (3)	100,0	g.s. trans; γγ 359,1 keV ; $T_{1/2}$= 135 ms
1020,4 (4)	9,2 (11)	
1065,4 (1)	6,8 (10)	
1103,9 (7)	5,9 (14)	
1354,3 (3)	20,1 (23)	g.s. trans.; doublet ^{129}In
1422,9 (5)	16,3 (14)	$T_{1/2}$= 166 ms
1585,7 (4)	9,0 (18)	
1689,6 (2)	7,2 (9)	
1761,2 (4)	17,5 (18)	$T_{1/2}$= 169 ms
1796,4 (2)	29,1 (32)	$T_{1/2}$= 186 ms
1835,0 (4)	n.a.	doublet
2087,9 (3)	6,8 (9)	
2155,3 (4)	8,2 (13)	
2216,7 (6)	8,4 (12)	
2460,4 (5)	3,4 (9)	
2997,6 (6)	1,2 (3)	
3183,9 (7)	3,3 (14)	
3346,9 (6)	4,6 (27)	
3701,3 (5)	4,9 (16)	
3913,9 (4)	7,0 (32)	
3966,8 (5)	6,1 (22)	

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