First γ-Spectroscopic Study of the N=82 r-Process "Waiting-Point" Nucleus ^{130}Cd

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Using a combination of the RILIS (Resonance Ionization Laser Ion Source) and neutron-converter systems at the PS-Booster CERN-ISOLDE to achieve highest possible selectivity of Cd-beam production, we have performed first γ–spectroscopic measurements of the 162-ms isotope $^{130}Cd_{82}$ [1]. This nuclide represents one of the most important classical, neutron-magic r-process "waiting-points".
^{130}Cd was first observed in 1986 by Kratz et al. [2] at the old SC-ISOLDE at CERN, starting the era of experiments in the r-process path. In those days, a β–decay half-life of (195+/-35) ms was determined by measuring β-delayed neutrons. It took more than 14 years, before three additional steps of selectivity allowed to repeat this measurement at the new PS-Booster ISOLDE, thus resulting in a more precise half-life of (162+/-7) ms [3].

Improvements at CERN-ISOLDE

The most important development was the installation of a Resonance Ionization Laser Ion Source (RILIS) to achieve chemical selectivity for elements with high ionization potentials. The RILIS allows us to run the ion source in two different modes. In the "laser off" mode we get only surface-ionized In (ionization potential 5.79 eV), whereas in the "laser on" mode we additionally get laser-ionized Cd (i.p. 8.99 eV). The second improvement was the use of a "neutron-converter", which acts as a kind of "mini-spallation neutron source". Instead of impinging the 1 GeV proton-beam on the thick UC_x-C target, the beam is focussed onto a Ta- or W-rod next to the target. The produced reaction neutrons cause neutron-induced spallations in the target, thus suppressing the proton-rich isobars (e.g. 29-min ^{130}Cs) to a large extent. A further enhancement of selectivity was possible with the use of the "High Resolution Separator" (HRS, maximum mass resolution $M/\Delta M \simeq 10{,}000$). For a detailed description of these techniques, see [4]. Only with these technical improvements it was possible to identify 12 new γ–lines of ^{130}Cd β-decay and their γγ–coincidence relationships by comparing "laser-on" and "laser-off" spectra.

Gamma-lines of ^{130}Cd β-decay

Eight of the 12 identified transitions could be placed in a decay-scheme (see Fig. 2 in the subsequent annual report about "Decay Scheme of ^{130}Cd"). As expected from general shell-model considerations, we observe a single strong Gamow-Teller transition to a low-lying $J^\pi=1^+$ level. This state with a two-quasi-particle configuration of $[\pi g_{9/2} \otimes \nu g_{7/2}]$ could be unambiguously determined by a ground-state transition and two γ-cascades [5]. The surprising result compared to recent shell-model predictions is its position at 2.12 MeV. This high excitation energy requires a rather high Q_β value of ≃8.5 MeV in order to obtain a physically consistent picture of ^{130}Cd β–decay [4].

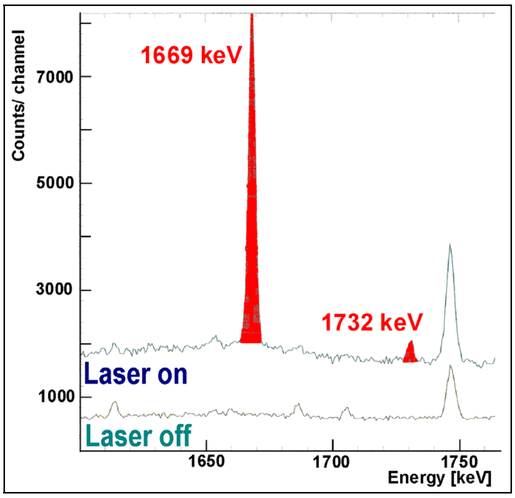

Fig. 1: Comparison between "laser-on" (Cd + In) and "laser-off" (only In) γ-singles spectra at A=130. Marked in red are two transitions of ^{130}Cd β-decay, including the strongest γ-line at 1669 keV.

The γ-line at 315.6 keV could be identified as $1/2^+ \rightarrow 3/2^+$ ground-state transition in the β-decay of the 1.23-min βdn-daughter ^{129}In to ^{129}Sn. From its intensity, a P_n-value of ≃5% for ^{130}Cd could be deduced. This value is in good agreement with our previous value of 3.5 (±1)% [3].

Table 1: Identified γ-lines and relative γ-intensities of ^{130}Cd β-decay. In the column "comment" are shown the γγ-coincidence relationships as well as ground-state transitions identified so far.

E_γ [keV]	$I_{\gamma,rel}$ [%]	Comment
315.6 (3)	3 (1)	^{129}In; βnγ
451.2 (2)	94 (9)	γγ 1669.2
949.8 (5)	20 (7)	γγ 1170.5
1082.0 (3)	1.8 (9)	
1138.2 (3)	2 (1)	
1170.5 (2)	30 (3)	γγ 949.8
1314.8 (3)	2.8 (9)	
1669.2 (2)	100	γγ 451.2
1731.7 (4)	4.6 (5)	
2120.3 (3)	17 (3)	g.s. trans.
2804.8 (5)	1.3 (4)	
4633 (1)	1.5 (4)	g.s. trans.
5098 (2)	0.8 (3)	g.s. trans.

References
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