Beta-decay half-lives of ^{129g,m}Cd and ^{133}Cd

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Beta-decay half-lives of very neutron-rich cadmium isotopes were determined at CERN-ISOLDE using the isobaric selectivity of the RILIS ion source. Beta-delayed neutron measurements resulted in an improved half-life of ^{129g,m}Cd and the first measurement of ^{133}Cd [1].

The region around the doubly magic ^{132}Sn has been the subject of several experimental investigations in the last years. The main reason for this big interest is the *N*=82 "waiting-point" area, where the r-process matter flow climbs up the shell closure from ^{125}Tc (*Z*=43) to ^{130}Cd (*Z*=48). The process is able to break out of the shell closure in the indium chain (*Z*=49) and rushes from there towards the next neutron-magic "waiting-point" area at $A \simeq 195$.

Production and ionization of Cd isotopes

Neutron-rich medium-mass isotopes are normally produced at ISOLDE by high energy (1–1.4 GeV) proton-induced spallation of ^{238}U. This method produces also large amounts of proton-rich Rb and Cs isotopes. To avoid this problem, a "neutron-converter" was used.

The Cd isotopes were ionized by a laser ion source (RILIS) in three steps. The frequency of the first step lies in the ultra-violet of the spectrum and is done by frequency tripling with two BBO crystals. The ionization efficiency is about 10%. The disadvantage of this method is the unavoidable background of surface ionized species, in this case mostly In. This problem is not solved yet.

Half-life measurements

After ionization and isobaric separation, the nuclides were implanted on an aluminum tape of the Mainz tape station. Beta-delayed neutron (βdn) data were taken with our Mainz 4π neutron detector, consisting of 64 ^{3}He proportional-counter tubes arranged in three concentric rings in a polyethylene matrix.

Table 1: Comparison of experimental β-decay half-lives, literature values and QRPA model predictions

Nuclide		$T_{1/2}$(exp.) [ms]	$T_{1/2}$(Lit.) [ms]	$T_{1/2}$(QRPA (FY)) [ms]	$T_{1/2}$(QRPA (Nilsson)) [ms]
^{129}Cd	g	242 (8)	270	457	308
	m	104 (6)	-	369	252
^{133}Cd		57 (10)	-	140	46

The results of these measurements are summarized in Table 1 and Figures 1 and 2. The results are compared with literature values and QRPA predictions from a "folded Yukawa"-potential (FY) or from the Nilsson model.

In the data of ^{129}Cd an interesting effect occurs: the delayed neutrons from the isomeric $\nu d_{3/2}$ state are mostly detected in the inner ring of the neutron counter, whereas the neutrons from the $\nu h_{11/2}$ ground state (g. s.) decay are detected mostly in the outer ring.

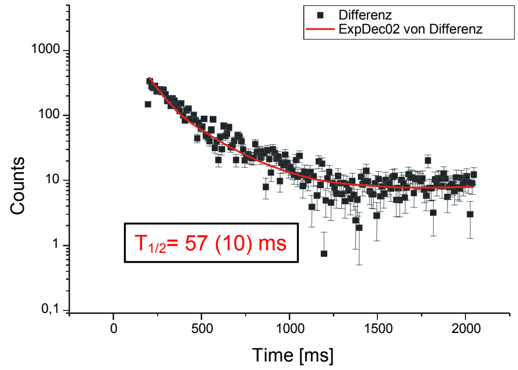

Fig. 1: Delayed neutron spectrum of ^{133}Cd with the half-life of $T_{1/2}$=57 (10) ms. The background is mainly due to the β-delayed neutron daughter ^{132}In with $T_{1/2}$ = 206 (5) ms.

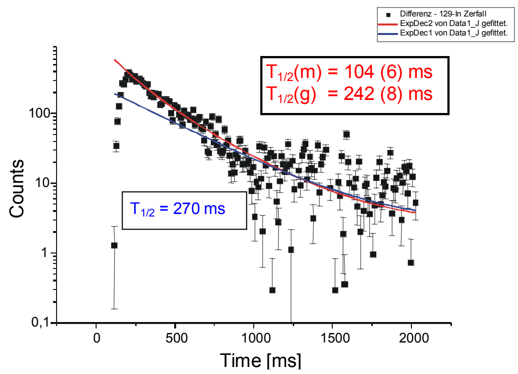

Fig. 2: Delayed neutron spectrum of ^{129}Cd. The blue line shows the simulated decay of ^{129}Cd with the half-life of 270 ms given in the literature.

The explanation of this effect are the different angular-momentum barriers for the emitted βdn´s. Neutrons emitted after β-decay of the $\nu d_{3/2}$ state have low angular momenta. This means, the average energy of these βdn´s is relatively low. Due to the thermalisation in the matrix of the neutron counter, these neutrons are predominantly detected in the inner ring. Neutrons emitted after the β-decay of the $\nu h_{11/2}$ g. s. have, due to their higher angular momenta and the correponding γ-competition, higher energies. Therefore, more matrix material is required for thermalisation and the βdn´s are detected in the outer ring. This effect is clearly visible in the experimental data. In the outer ring the measured half-life is close to the literature value, in the inner ring clearly two half-lives are observed.

References

[1] O. Arndt, *Diplomarbeit* (2003)