Decay-Scheme of ^{130}Cd

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With the technical improvements and results described in the preceding annual report about "First γ–Spectroscopic Study of the N=82 r-Process "Waiting-Point" Nucleus ^{130}Cd", we were able to collect $\beta\gamma$–coincidence data and to determine the Q_β-value for ^{130}Cd. This result completed our earlier investigations and allowed to propose a first β–decay scheme of ^{130}Cd, that can be compared to shell-model predictions.

Decay scheme

The most important nuclear physics quantities in this context are the excitation energy of the lowest 1^+ 2QP state and its log ft value for Gamow-Teller (GT) feeding. The input data needed to calculate the log ft are the GT-decay energy, which is deduced from the difference between the Q_β-value and the E(1^+), the β-decay half-life of 162 ms and the β-feeding of 69%. The predictions for the Q_β-value of ^{130}Cd lie between 8.93 MeV from mass models with shell-quenching (e.g. HFB-SkP and ETFSI-Q) and 7.43 MeV from the unquenched FRDM, while the Audi and Wapstra mass evaluation [1] leads to a value of 8.5 MeV. Our experimental value of 8.32 MeV [2] was deduced from a simplified Fermi-Kurie plot (see Fig.1) and confirms those high values from quenched models. This Q_β value is needed in order to obtain a physically consistent picture of ^{130}Cd β-decay.

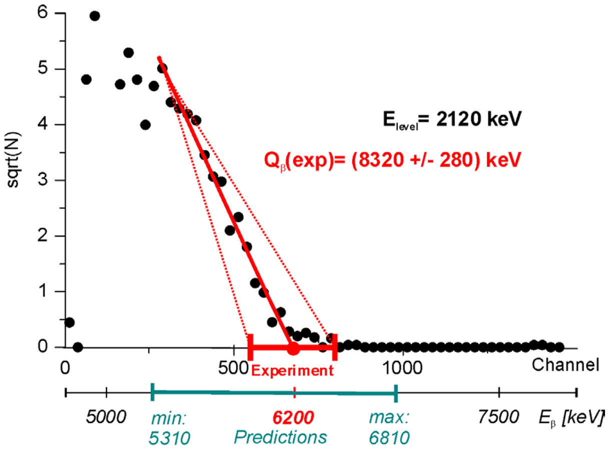

Fig. 1: Simplified Fermi-Kurie plot for ^{130}Cd. Shown is the summation over all five transitions, that come from the 1^+ level at 2120 keV. From its x-axis intercept, a β-endpoint energy of 6200 keV was derived.

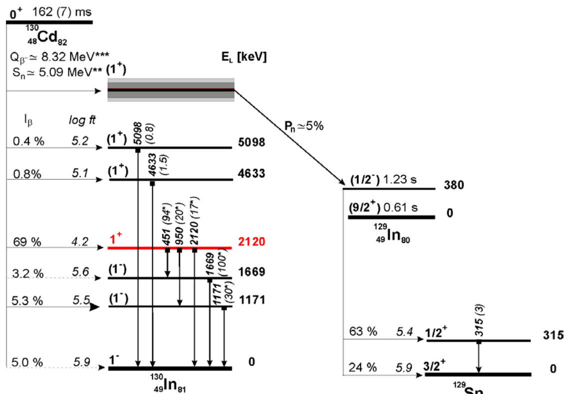

Fig. 2: Decay scheme of ^{130}Cd. The S_n-value is taken from [1].

With these data, a log ft value of 4.2 for the $0^+\rightarrow1^+$ GT-transition was deduced. The β-feeding of the ground-state suggests a first-forbidden (ff)-transition, while the log ft's of the levels at 1669 keV and 1171 keV lie between the usual values for GT- and ff-decays.

OXBASH model predictions

Fig.3 shows a comparison of the experimental level scheme of ^{130}In with two calculations of the OXBASH model [3,4]. Prediction (A) was made before knowing our results, and the position of the $[\pi g_{9/2}\otimes\nu g_{7/2}]$ 2QP 1^+-state was calculated to 1382 keV. This theoretical E(1^+) was considerably lower than our experimental value of 2120 keV. In the recalculation labelled (B), the 1^+ level could be lifted to 1874 keV by weakening the interaction of the $[\pi g_{9/2}\otimes\nu g_{7/2}]$ two-body matrix element. Apart from the above state, the three low-lying 1^- levels are also of interest, because the may be populated by ff-transitions. The two high-lying 1^+-states of 4QP nature at 4633 keV and 5098 keV are beyond the present model calculations, since they require core-breaking.

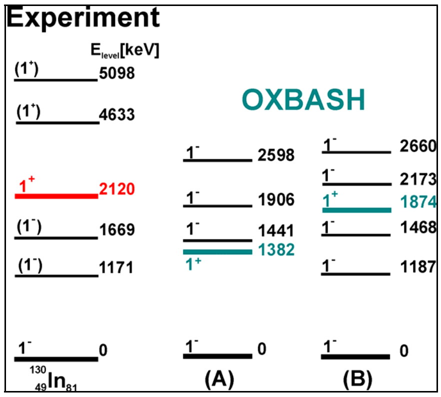

Fig. 3: Comparison of low-lying 1^+ and 1^- levels in ^{130}In with two calculations of the OXBASH shell model. Marked in red and blue are the positions of the lowest 1^+ level.

Astrophysical implications

The high experimental Q_β-value of 8.32 MeV is another evidence for a "quenching" of the N=82 shell below ^{132}Sn [5]. As a consequence of the weakening of the $\pi\nu$–monopole interaction, the half-lives for GT-decay of the so far unknown N=82 waiting-point nuclei ^{128}Pd, ^{127}Rh, ^{126}Ru and ^{125}Tc will become longer than predicted by recent shell models. This leads to a more reliable description of the build-up of the A≈130 $N_{r,\odot}$ peak in r-process abundance calculations. Hence, a better understanding of the r-process matter flow through this "bottle-neck" region is derived, which also determines to a large extent the total duration of a classical r-process.

References

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