SPECTROCOPY OF THE T_z=1 NUCLEI CLOSE TO ^{100}Sn *

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The two nuclei ^{98}Cd and ^{102}Sn, closest neighbours of ^{100}Sn, have been studied with a recoil catcher setup, following the reactions: ^{58}Ni(^{46}Ti, α2n)^{98}Cd and ^{58}Ni(^{50}Cr, α2n)^{102}Sn. Long lived isomeric states were measured in ^{98}Cd $I^{\pi} = (8^{+})$, $t_{1/2} = 0.48(8)$ μs and in ^{102}Sn $I^{\pi}=(6^{+})$ with $t_{1/2} = 1.0(6)$ μs. The proposed experimental level schemes of the isomeric decay are presented and compared to the shell model predictions.

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1. Introduction

Since ^{100}Sn was observed in the heavy ion fragmentation experiment [1, 2], the interest in the structure studies of this nucleus increased substantially. The excited states in ^{100}Sn and its one–particle (hole) neighbours are not known. Therefore, the shell structure of ^{100}Sn has to be deduced from excited states in more remote nuclei that are accessible with stable beam and target combinations. The so far closest experimental approach to ^{100}Sn is described by the $T_z = 3/2$ nuclei ^{97}Ag [3], ^{99}Cd [4], ^{101}In [5], and by two $T_z = 1$ nuclei, as a result of the most recent experiment, namely ^{98}Cd [6] and ^{102}Sn [7]. The excited states structure of ^{98}Cd and ^{102}Sn nuclei as the two proton hole and two neutron particle spectrum in ^{100}Sn respectively are discussed here in the frame of work shell model predictions.

2. Experimental results and discussion

The experiment was performed at the Tandem Accelerator Laboratory of the Niels Bohr Institute in Risö. There were two separate runs of the ^{58}Ni beam at the energy of 215 MeV and 225 MeV bombarding 1mg/cm^2 thick targets of ^{46}Ti and ^{50}Cr aiming for studies of ^{98}Cd and ^{102}Sn, respectively. The compound nuclei in this reactions were spaced by one α particle. Both nuclei of our interest were produced after the evaporation of α2n from compound nuclei. In case of ^{98}Cd as well as in ^{102}Sn long lived isomers were expected [8, 9] that required use of a special detector setup for an exclusive isomeric γ decay study.

Around the target there were a 4π Silicon ball with 31 elements, the Neutron wall with 15 elements and 5 large BaF_2 detectors mounted to give a time reference of the nuclear reaction and the possibility of exit channel identification. 60 cm downstream from the target, where the recoil nuclei were stopped on the catcher foil, the two CLUSTER Ge [10] detectors were mounted in a compact geometry. The γ–rays delayed at least by the flight time of the recoil nuclei (about 50 ns) were measured. Further experimental details can be found in Ref. [11].

In the Ti experiment a new γ–ray cascade of 4 transitions (Fig. 1) was observed, which from its coincidence intensities with α particles and neutrons could be assigned as the (α2n) exit channel from the ^{104}Sn compound nucleus, *i.e.* to ^{98}Cd. Similarly the two γ–rays cascade that was in coincidence with one α particle and two neutrons evaporated from ^{108}Te* was assigned to ^{102}Sn. Details of the exit channel identification are given elsewhere [6, 7]. The half–life of seniority isomers were measured and determined to 0.48(8) μs in case of $I^\pi = (8^+)$ in ^{98}Cd [6] and 1.0(6) μs in case of $I^\pi = (6^+)$ in the ^{102}Sn [7] nucleus. In Fig. 2 the proposed level scheme

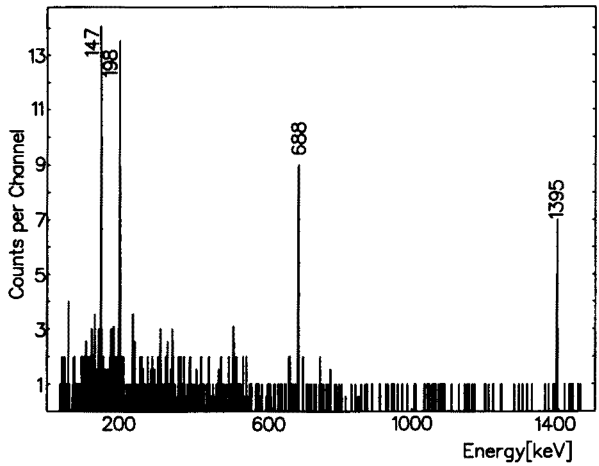

Fig. 1. Sum coincidence spectrum of ^{98}Cd gated with $1\alpha2$n.

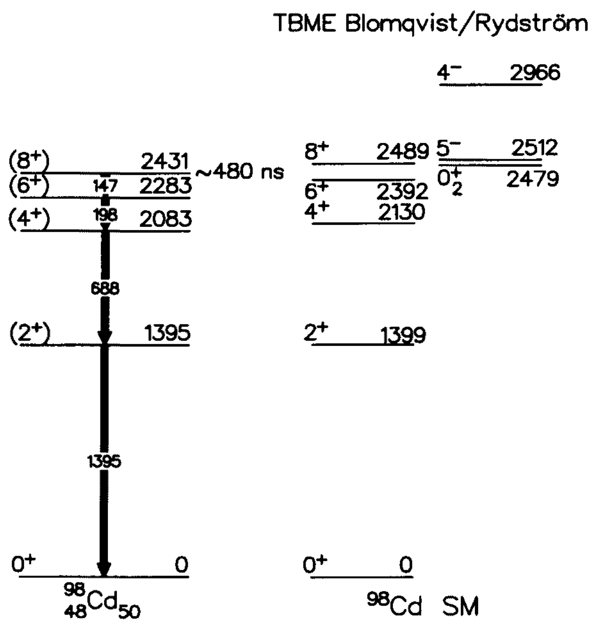

Fig. 2. Proposed experimental level scheme of ^{98}Cd on the left and the shell model predictions on the right hand side.

for the isomeric decay of ^{98}Cd nucleus is shown. The spin assignment and the level ordering could not be determined from the experiment [6], but it was deduced from the systematics of the $I^{\pi} = 8^{+}$ isomeric γ decay in the $N = 50$ isotones. On the left hand side there are shell model predictions shown for an empirical set of two body matrix elements [12] fitted to energy levels in $N = 50$ isotones. The agreement between experiment and theory is very good, although deviations up to 100 keV are found for the $I^{\pi} = 4^{+}$, 6^{+}, 8^{+} states. The measured half – life of the isomeric state and the energy of 147 keV of the primary γ ray provide a B(E2) value that is almost a factor of two smaller than the calculated value. Since ^{98}Cd gives the pure two–proton holes spectrum in ^{100}Sn nucleus in a ($p_{1/2}$, $g_{9/2}$) model space, the possible source of the disagreement would be the effective proton charge used in the calculations. The value of the effective charge value of 1.7 e, widely used for nuclei from the region including ^{96}Pd, would have to be reduced to $e_{\pi} = 0.84(10)e$ for the ^{98}Cd nucleus.

The $B(\mathrm{E2};6^{+}\rightarrow4^{+})$ value for the case of the ^{102}Sn nucleus could not be determined since the transition depopulating the isomer, predicted to have an energy smaller than a 100 keV, was not observed. The tentative assignment of $I^{\pi} = 6^{+}$ to the isomeric state is based on systematics of Sn isotopes

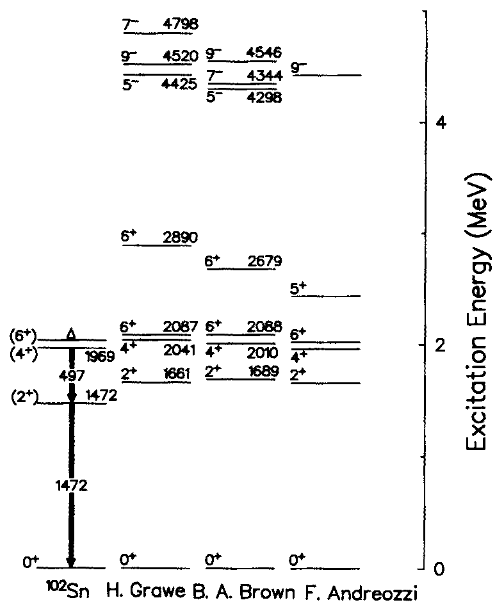

Fig. 3. Comparison of experimental level scheme of ^{102}Sn with the three different shell model predictions.

and on the fact that a highly converted low energy E2 transition could not be observed at our level of statistical uncertainties. In Fig. 3 the proposed level scheme is shown in comparison to shell model calculations [13, 14, 15] using empirical and realistic interactions. Each of the prediction give the $I^\pi = 2^+$ state energy about 200 keV too high, what could be caused by the too strong ground state pairing interaction used in the calculations. The energy of the first transition below the isomer is predicted with a maximum energy of 78 keV, which with the known lifetime corresponds to a $B(\text{E2};6^+\rightarrow4^+)$ value of 1.3 Wu. This would allow to set a lower limit for the neutron effective charge of 0.8 e that confirms a large value needed also for ^{104}Sn [16].

In conclusion the focus on delayed spectroscopy allowed for structure studies of the two two quasi–particle neighbours of ^{100}Sn for the first time. This opens also possibilities for further experiments in prompt spectroscopy of higher excited states of those nuclei to scan single particle structure and core excited states of ^{100}Sn.

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