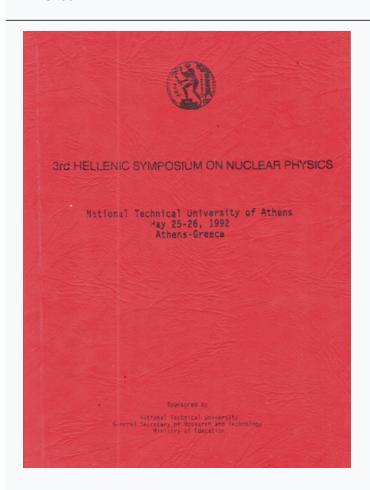




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Level Scheme of 102 In first observed

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Abstract

Neutron deficient nuclei close to 100Sn have been investigated in-beam by particle and y-ray spectroscopic methods using the NORDBALL detector array following the bombartment of a 54 Fe target with a beam of 270 MeV 58 Ni. Protons and α particles were identified with a 4π ΔE -type Si-multidetector and neutrons with a 1π liquid-scintillator-detector-assembly placed in the forward derection. Excited states of 102 In were identified for the first time. The level scheme constructed from γ - γ particle-coincidence and y angular correlations is discussed and compared to the structure of neighboring nuclei in the framework of the nuclear shell model.

1. Introduction

Since 100Sn is the heaviest self-conjugate double magic nucleus nuclei close to it are of greate interest in testing the validity of the nuclear shell model. Receptly several such nuclei have been identified in-beam like 104Sn[1], 105Sn, 103In[2], and 100,101Cd[3]. In the present work we try to extend our knowledge in the 100Sn region by using the NORDBALL suitably improved for this purpose.

2. Experiments and results.

In order to reach nuclei closer to $^{100}{\rm Sn}$ than achieved earlier, a beam of 270 MeV $^{58}{\rm Ni}$ was used to bombard a target of $^{54}{\rm Fe}(10{\rm mg/cm^2},$ 99.8%). The experiment was performed at the Tandem Accelerator Laboratory of the Niels Bohr Institute at Riso-Denmark. The NORDBALL detector array [4] was optimised to yield high selectivity for defferent reaction channels and consisted of 15 Ge-BGO detectors (one being a LEP detector) for v-ray identification ,a 4n detector system comprised 21 $\Delta\text{E-type}$ Sidetectors [5] optimised for proton and a particle identification, a 1n neutron wall which comprised 11 liquid scintillator detectors in the downstream hemisphere [6] and a 2n γ -ray calorimeter composed of 30 BaF2 crystals covering the upstream hemisphere. A major emphasis was put on the performance of the neutron detector system. The reason is that the compound nucleus ^{112}Xe is very neutron deficient and the evaporation of neutrons (being of course rare) produce the most exotic nuclei which are of the greatest interest. The neutron- γ separation was improved by almost an order of magnitute compared to the pulse shape discrimination technique by combining this technique with neutron time of flight. A total of 420 million γ - γ -coincidence events containing information about the detected γ rays, neutrons, protons and a particles were collected.

In analyzing the data we sorted γ - γ coincidence matrices gated by different multiplicities of detected neutrons, protons and a particles. From these matrices corresponding to various exit channels of the reaction we calculated and compare the intensity of the observed γ -ray transitions. Since the intensity ratio depend on the multiplicities of particles acompanying γ emission and on the particle detection efficiencies and these efficiencies depend very weakly on the reaction channel for a specific type of detected particle, comparison of such ratios with ratios for γ rays from previously known nuclei that were populated in the experiment make the assignment of the final nuclei possible. Results of such a comparison is shown in Fig.1 for the 145 keV line, which is a candidate for a transition in 102In. Using the above method a total of 29 different exit channels were identified including 7 light In, Sb. Te and I isotopes not observed before [7]. The experimental yield for 102In was estimated to be 0.03% of the total yield (0.004% for the weakest observed channel 100Cd). This shows the extremely high selectivity of the present experimental set-up.

3. Level scheme.

Transitions assigned to 102 In are shown in Fig.2, and the proposed level scheme in Fig.3. Some transitions in Fig.2, which belong to 102 In could not be placed in the level scheme (272 and 459 keV), or were placed only tentatively (382, 376, 250 and 222 keV) due to low statis-

tics in the individual gates.

Using a simplified γ - γ correlation analysis we obtain the multipolarities of the observed transitions. In this analysis the γ transitions from the γ - γ coincidence matrices gated with the right combination of evaporated particles were sorted at three detector angles with respect to the direction of the beam i.e. 79 ,101 ,143 . The intensity ratios I(143)/I(79)+I(101) were then calculated for the transitions in 102In and compared to ratios obtained for transitions of known multipolarity. In this way it is found that all transitions observed in 102In have a dipole character (most likely M1) except for the 1137 keV transition which has a quadrupole character (most likely E2). The spins and parities of the levels in 102In were assigned assuming that all observed transitions are stretched and the ground state is a 6+ in accordance

with ¹⁰⁴In. Therefore the spins and parities in Fig.3 are tentative.

4. Discussion

The proposed level scheme of 102 In resembles the low energy part of the level scheme of 104 In [8] and both of them differ from $^{106-116}$ In in that in 102 In and 104 In the negative parity states are expected to lie higher in excitation energy (as has been observed in 104 In [8]) compare to the heavier In isotope. The negative parity high spin states in $^{106-116}$ In were explained as a 19 9/2 0 19 1/2 multiplet coupled to a quadrupole phonon excitation of the underlying core [9]. The 6+ ground states in 102 In and 104 In have a 19 9/2 0 19 9/2 configuration. The lowest lying (7+) state of 104 In is interpreted as the 7+ state of this multiplet. The (7+) and (8+) states in 102 In are suggested to belong to the 104 10/2 configuration and correspond to the second excited the πg^{-1} 9/2 0 vg7/2 configuration and correspond to the second excited 7+ and first excited 8+ states in 104 In. In 102 In one of the 7+ states is not observed.

Regarding the higher lying states these are mainly due to three quasineutrons in the $d_{5/2}$ and $g_{7/2}$ coupled to a $m_{5/2}$ proton hole if a $100\,\mathrm{Sn}$ core is assumed. The results of advanced shell model calculations using a $90\,\mathrm{Zr}$ core and a configuration space consisting of the $m_{5/2}$, $m_{5/2}$, not observed experimentally probably because of low statistics.

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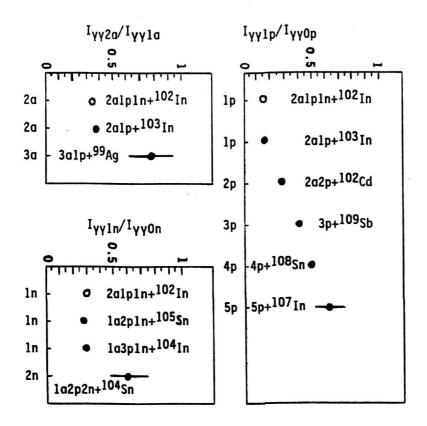


Fig.1. Intensity ratios for different proton ,neutron and a particle multiplicities. Comparison with transitions corresponding to known final nuclei clearly assign the 145 keV transition to the 2 α plan exit channel, i.e. 102 In.

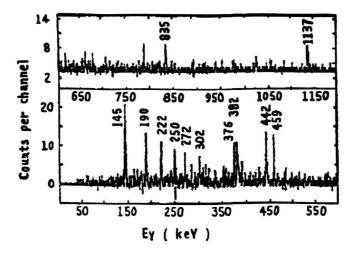


Fig.2. Summed coincidence spectrum for 102In obtained from the 2 α lpln and 2 α ln gated γ - γ matrices.

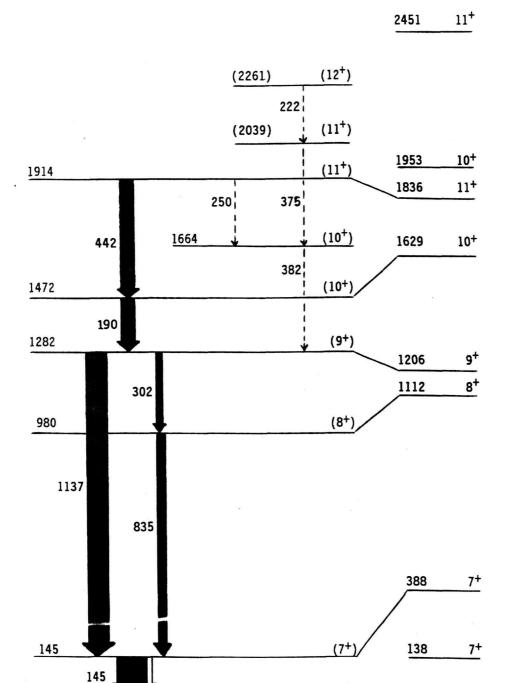


Fig.3. Experimental and theretical level schemes of $102\,\mathrm{Im}$. The widths of the arrows show the intensities of the transitions in the coincidence projection. The white parts of the arrows show internal conversion contribution.

EXPERIMENT

0

102_{In}

 (6^{+})

0

THEORY

6+