COEXISTING STRUCTURES IN ^{116}Sn FROM WEAK FUSION-EVAPORATION REACTIONS * **

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Excited states in ^{116}Sn have been studied by using the DORIS Ge array combined with charged particle detectors. High-spin states were observed up to $I \approx 20\hbar$ region. Spherical as well as regular, deformed level structures were found. The spherical states are interpreted to arise from pure neutron configurations, while the deformed, intruder bands are most likely to involve the proton $2p-2h$ excitations across the $Z=50$ shell gap.

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Many of the collective properties of low-lying states in stable even-mass Sn nuclei can be reproduced by neutron-quasiparticle calculations. However, strong population of low-lying 0^+ states in two-proton transfer reactions evinced that intruder 2 proton–2 hole configurations are also present in these states [1]. Rotational patterns up to 12^+ states based on these deformed $\pi g^2_{7/2}g^{-2}_{9/2}$ structures were identified by Bron *et al.* [2]. High E2 and E0 rates between the low-spin states of stable even-mass Sn nuclei observed by Kantele *et al.* [3, 4] were associated with the intruder structures. Later the bands in ^{112}Sn and ^{114}Sn have been extended to higher spins [5, 6] and new bands involving also $h_{11/2}$ protons and exhibiting a smooth band termination phenomenon have been identified to very high spin in light Sn isotopes [7, 8].

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As the intruder mechanism in Sn nuclei is thought to be due to the interaction between protons and neutrons in spin-orbit partner orbits ($\pi g_{7/2}\nu g_{7/2}$), the corresponding intruder states should minimise their energies at N = 66 *i.e.* in ^{116}Sn. This nucleus was extensively studied by the Jyväskylä-Uppsala collaboration in its low-spin states [3] but it is very difficult to produce it in heavy-ion reactions and consequently, to extend the high-spin systematics of Sn nuclei towards the neutron midshell.

Fortunately, relatively high-spin states of ^{116}Sn can be excited by utilizing weak fusion channels involving both neutron and alpha-particle evaporations. In the present work we used the ^{104}Ru(^{18}O,α2n)^{116}Sn reaction. In the first part of the experiment a 0.6 mg/cm^2 thick target on a 5 mg/cm^2 gold backing was bombarded with 65 MeV ^{18}O ions from the Jyväskylä K130 cyclotron. To prevent Doppler broadening of high-energy γ-rays from short living high-spin states a second run with an unbacked target was also carried out.

For resolving the weak (^{18}O,α2n) channel ($\approx$ 1 % of the 4n channel) from the dominant xn-channels, an array of 12 Si-PIN diodes (10 x 10 mm, 300 μm thick) was used in the charged-particle detection. The diode windows were covered with tantalum absorbers to stop elastically scattered ^{18}O ions. The array covered about 30% of the 4π solid angle. Gamma-rays were detected by the DORIS array consisting of 12 Compton suppressed Ge detectors. Gamma-gamma coincidences as well as $\gamma\gamma$-particle coincidences were collected. The $\gamma\gamma$-coincidence data with a proper gate on the PIN diode alpha spectrum resulted in very clean γ-ray spectra for ^{116}Sn (Fig. 1).

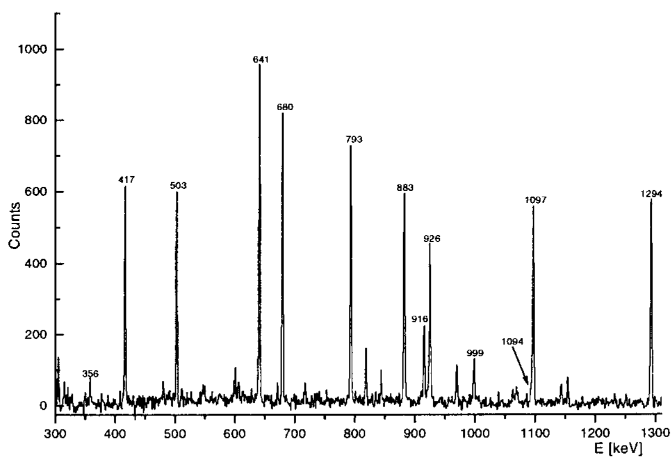

Fig. 1. A summed coincidence spectrum with gates set on the 680, 793 and 883 keV transitions.

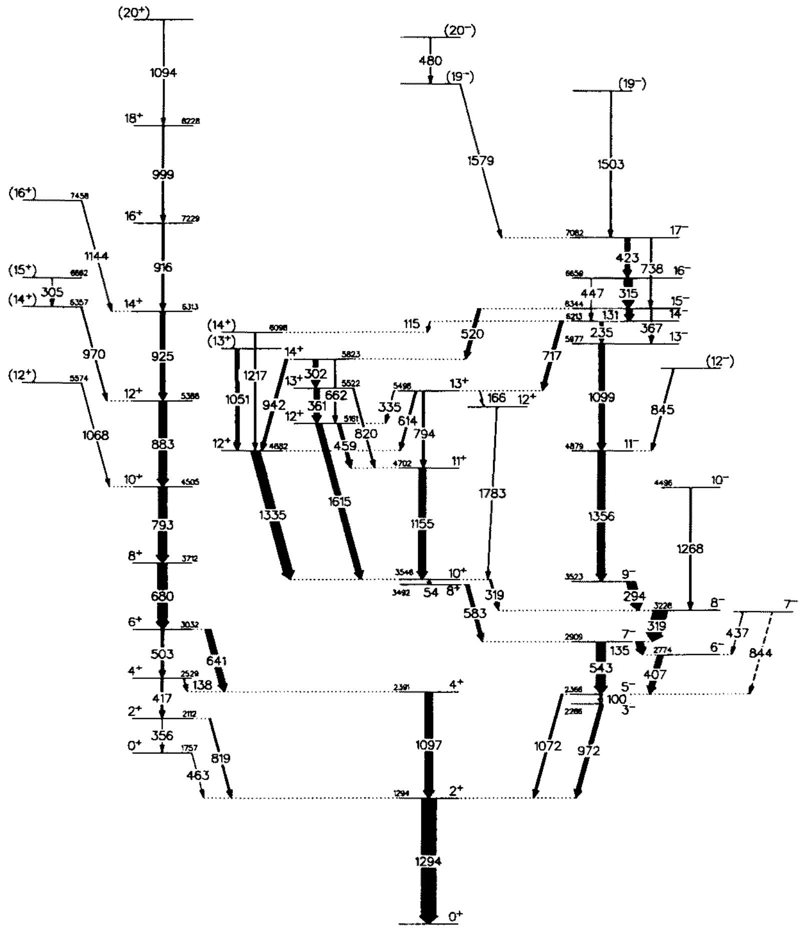

Fig. 2. Level scheme of ^{116}Sn.

Based on the coincidence relations and angular distribution information the level scheme of Fig. 2 was contructed. It reveals an excellent example of two independent coexisting structures. As observed in Ref. [3] the intruder structures at low spin are mixed with the normal structures and therefore the band is not as well-developed at low energies as it is at higher spin, where it does not show any connection to the normal states. An alignment, obviously associated with $h_{11/2}$ neutrons, can be observed in the intruder band. This alignment takes place at $\hbar\omega = 0.45$ MeV, which is somewhat higher than in lighter Sn isotopes. Also the alignment gain is less than in the lighter isotopes. This may be due to the fact that the Fermi surface is moving up from the low Ω $h_{11/2}$ orbits when N increases.

The other part of the level scheme consists of neutron-quasi-particle and collective core excitations. The low-lying 5^-, 7^-, 9^- and 10^+ states have been interpreted to arise from the neutron shell-model $h_{11/2}s_{1/2}$, $h_{11/2}d_{3/2}$, $h_{11/2}g_{7/2}$ and $h^2_{11/2}$ configurations, respectively [2]. The level energy spacings above the 9^- state are similar to those of the collective 2^+_1 and 4^+_1 states and therefore we associate the 11^- and 13^- states with the $h_{11/2}g_{7/2}\otimes 2^+$ and $h_{11/2}g_{7/2}\otimes 4^+$ configurations. Negative parity states with higher spins can be built by using the known 2-quasiparticle states as building blocks. The configurations $h^3_{11/2}s_{1/2}$, $h^3_{11/2}d_{3/2}$ and $h^3_{11/2}g_{7/2}$ yield states with I_{max} = 14, 15 and 17, respectively, presumably corresponding to the observed negative parity states at 6213, 6344 and 7081 keV.

The positive parity $I > 10$ states may be due to the coupling of the $h^2_{11/2}$ 10^+ state with the collective yrast 2^+ and 4^+ states, or due to pure shell-model neutron configurations where the $h^2_{11/2}$ state is coupled to two neutrons occupying the $s_{1/2}$, $d_{3/2}$ and $g_{7/2}$ orbitals.

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