Coexisting Single-Particle and Collective Structures in ^{137}Sb

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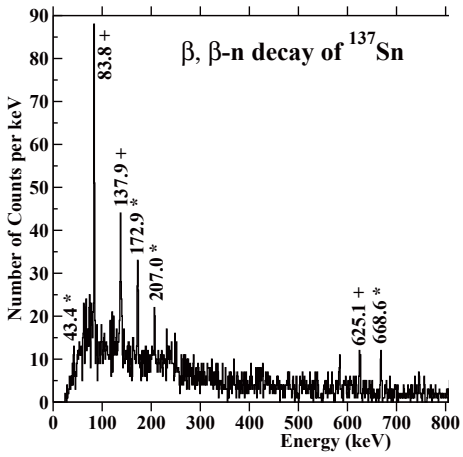

Fig. 1. γ-ray spectrum obtained from the β-decay of ^{137}Sn in the current work.

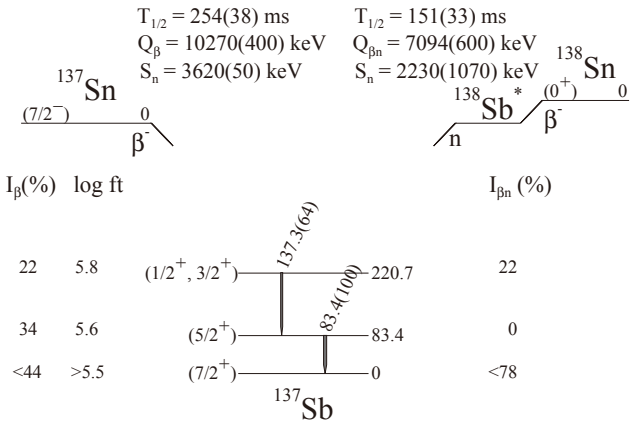

Fig. 2. Level scheme of ^{137}Sb obtained in the current work.

The structure of the nucleus is governed by a delicate interplay between single-particle and collective states. Currently it is unclear how collective modes develop in nuclei in very neutron-rich regions far from stability, which are difficult to access experimentally. Collectivity occurs when the integrated proton-neutron interaction is able to overcome the pairing force. Experimental measurements have shown that reduced pairing was found to be necessary to correctly describe the structures of ^{136}Sn[1)] and ^{72,74}Ni,[2)] which possess significant seniority (broken pair) mixing. It is therefore interesting to search for the development of collective modes in nuclei east of ^{132}Sn. The very neutron-rich nucleus ^{137}Sb consists of a single valence proton coupled to ^{136}Sn and its structure is most appropriate for testing the proton–neutron part of shell-model effective interactions. A decay scheme of this nucleus has been constructed via β- and β-n decay spectroscopy data taken at RIBF, RIKEN during the EURICA campaign.

The experimental spectrum obtained is presented in Fig. 1. It was possible to construct a first level scheme using $\gamma - \gamma$ coincidences, along with the β-n decay data of ^{138}Sn, shown in Fig. 2. The ground state spin of the parent ^{137}Sn nucleus was determined from the β-n feeding of known spin (4^-) and (2^-) levels in ^{136}Sb. The ^{137}Sb ground-state spin of $(7/2^+)$ was assigned from the β and β-n feeding intensities to levels in ^{136,137}Te. In particular the observed feeding to spin $(2^+) - (6^+)$ levels in ^{136}Te agrees best with a $(7/2^+)$ ground-state spin assignment. It is important to note that the first excited state in ^{137}Sb receives no direct feeding from the β-n decay of ^{138}Sn, allowing a spin of $(5/2^+)$ to be assigned.

The experimental level scheme has been compared to the results obtained from shell-model calculations[3)] and level systematics. The calculations predict a set of four low-lying states with spins of $1/2^+, 3/2^+, 5/2^+$, and $7/2^+$ all within an energy range of 0–400 keV, with other states in this spin range at energies >700 keV. As three low-lying states in ^{137}Sb appear to be fed directly from β decay there is considerable unseen population from the γ decay of higher lying levels.

The wavefunctions of the four lowest-lying states of ^{137}Sb are calculated to be different in nature. For example the $7/2^+$ state has a predominantly single-particle character, whereas the $1/2^+$ and $3/2^+$ states are more fragmented, with seniority-3, and higher, couplings making up >70% of the wavefunction. The latter is a sign of the breakdown of independent single-particle behavior and emergening collectivity. Indeed the theoretical results point towards the coexistence of single-particle and weakly collective states near the ground state of ^{137}Sb.

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