The Single Proton Nucleus $^{133}$Sb

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The $\beta$-decay of $^{133}$Sn, populating levels in the single proton valence nucleus $^{133}$Sb, has been studied. The observed energy levels and $\beta$-transition probabilities are discussed in terms of the shell model.

1. Introduction

The $^{132}$Sn nucleus exhibits one of the strongest shell closures among the few doubly closed shell nuclei. The four isotopes having one nucleon (or nucleon hole) outside the $^{132}$Sn core should therefore provide unusually clear examples of how a single particle (hole) moves in the nuclear field, i.e. the shell model.

So far, only $^{131}$Sn, the neutron hole case, has been studied extensively. In contrast, the two most unstable valence nuclei $^{131}$In and $^{133}$Sn (the proton hole and the neutron particle cases, respectively), are completely unknown.

The aim of the present work is to enlarge the scarce information on the single proton nucleus $^{133}$Sb, the fourth and last member of the valence nuclide family around the doubly closed shell nucleus $^{132}$Sn. The pioneering work of Holm et al. from 1970 [1] showed how the lowest state of $^{133}$Sb was populated in the $\beta$-decay of $^{133}$Sn. By performing basically the same study, with improved technique, however, we are now able to observe numerous excited states up to above 6 MeV in the final nucleus. In addition to the present data, information on a few high spin states in $^{133}$Sb has been obtained in a study [2] of isomeric levels populated directly in the fission process.

So far, the only possible way to investigate the $^{132}$Sn region is by decay studies of fission products. Because of the complexity of the fission process, the use of an isotope separator is desirable.

2. Experimental Details

2.1. Source Production and $\gamma$-Ray Measurements

The $^{133}$Sn activity was studied at the OSIRIS online mass separator facility [3] in Studsvik. The performance of this facility for studies of short-lived fission product nuclei has been improved by more than a factor 20 since the previous rather limited investigation of the decay of $^{133}$Sn was made [1]. The activity now obtained, was therefore sufficient for relatively detailed spectroscopic studies. The main experimental difficulty was caused by the activities of $^{133}$Sb and $^{133}$Te which have considerably higher fission yields. They are also favoured by having longer half-lives than $^{133}$Sn, making them less affected by decay losses during the diffusion process in the ion source of the mass separator. The counting rate from the longer lived activities can be reduced to some extent by selection of a short collection time. In the $\gamma$-ray measurements, we used a cycle comprising 2.4 s of beam collection on a tape of Al coated Mylar foil, after which the source was rapidly transported to a shielded position where two consecutive $\gamma$-ray spectra were recorded with an interval of 1.2 s. The cycle was repeated about 27,000 times for the spectrum shown in Fig. 1. The $\gamma$-lines following the decay of $^{133}$Sn were easily identified by subtracting the second spectrum from the first. A listing of the $\gamma$-lines is given in Table 1 which also show the results of a $\gamma\gamma$-coincidence measurement made with two large volume Ge(Li) detectors. The sensitivity of
counts/Channel

133 Sn → 133 Sb

Channel number