Probing nuclear structure around doubly-magic ^{132}Sn through lifetime measurements

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Introduction

Nuclear structure studies around doubly magic ^{132}Sn are of contemporary interest and are being explored with different experimental techniques. One of the key focuses is on the measurement of nuclear level lifetimes and hence transition probabilities for the low lying levels as this provides direct insight into the nucleon-nucleon interactions [1-3]. Systematic measurements in nuclei around ^{132}Sn, having few proton particles away from Z=50 or few neutron holes away from N=82 are useful to understand the evolution of nuclear structure between two extreme double shell closures of ^{100}Sn and ^{132}Sn. However, the availability of spectroscopic information around ^{132}Sn is very scanty as there is experimental difficulty in reaching this region by compound nuclear or transfer reactions using the available target-projectile combinations. In this context, the measurement of nuclear level lifetimes in $^{130-132}$Te & ^{129}Sn is of extreme importance to understand the nucleon-nucleon interaction and the role of configuration mixing around double shell closure of ^{132}Sn. In the present work, lifetimes have been measured for the low lying levels in the ^{130,132}Te & ^{129}Sn nuclei using γ–γ fast timing technique (Generalized Centroid difference method) [4-5].

Experiment

The low lying excited states of ^{130,132}Te &^{129}Sn have been populated from the IT decay of higher lying μs isomeric levels in these Te & Sn nuclei, viz. 10^+, 1.9 μs in ^{130}Te, 10^+, 3.7 μs in ^{132}Te & $19/2^+$, 3.6 μs in ^{129}Sn. The neutron rich Te and Sn isotopes were produced through neutron induced fission at Institut Laue-Langevin (ILL) research reactor, Grenoble, France. The recoiling fission fragments were separated in mass and kinetic energy using the Lohengrin recoil fragment separator and were detected with an ionisation chamber (IC) placed at the focal plane. An array of four 1.5” X 1.5” $LaBr_3$(Ce) fast scintillator detectors placed at 90 degrees to each other and coupled with two Clover HPGe detectors were used for the detection of de-exciting γ radiations. The energy and time information from these detectors were obtained by digitizing the preamplifier outputs from the Clovers, the anode signals of the photomultiplier tubes (Hamamatsu 13435) connected to the $LaBr_3$ crystals & TAC outputs.

Analysis & Results

In the present experiment, TAC range used was of 100 ns which is suitable for fast timing measurements using Generalized Centroid Difference (GCD) method. Therefore, TAC output has been used for level lifetimes in picosecond range & lifetimes in ns range (up to 30ns). In GCD method, the difference of experimental centroid positions among the delayed and anti-delayed time distributions (ΔC_{exp}) generated for a particular γ–γ cascade is measured. Proper background correction has been done for lifetime measurement though GCD method in order to make results free from

Compton background. The slope method exploiting the $LaBr_3$-$LaBr_3$ time stamp difference data was utilized for the measurement of level lifetimes which are greater than 30 ns. Lifetimes ~ μs or more were measured using the time stamp difference data of delayed IC-Clover coincidences. The data analysis for the extraction of nuclear level lifetimes has been carried out using the SoCo2 analysis package.

From the present experiment, level lifetimes for 2_1^+, 4_1^+, 6_1^+, 7_1^-, 10_1^+ in ^{130,132}Te & $15/2^-$, $13/2^-$, $15/2^+$, $19/2^+$,$23/2^+$ in ^{129}Sn has been determined

Among which results for 4_1^+ in ^{130,132}Te and & $15/2^-$, $13/2^-$, $15/2^+$ in ^{129}Sn are new. Some of the initial results from this measurement has been presented at 64th DAE-BRNS symposium on Nuclear Physics [6].

Discussion

The reduced transition probabilities B(E2) corresponding to the decay of low lying levels in ^{130,132}Te & ^{129}Sn have been deduced from the measured lifetimes. In order to interpret the results, Large Basis Shell Model (LBSM) calculations has been performed for these nuclei. Different effective charges were used to reproduce the experimentally obtained results. One representative plot which consists of the B(E2) transition probabilities as a function of angular momentum for low lying yrast levels in ^{130,132}Te obtained with shell model calculations along with the experimental results are shown in fig 1. Experimental results have also been compared with results from EPPQ calculation [7].

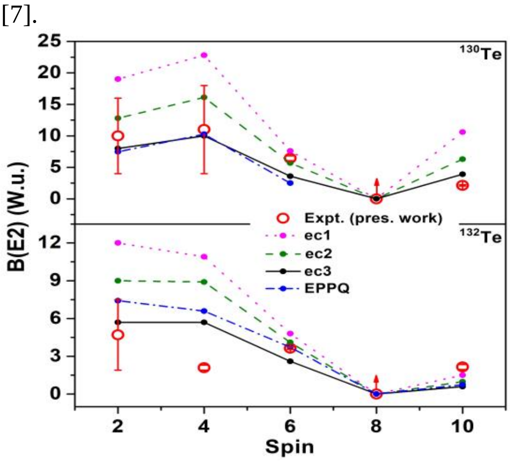

Fig 1: Experimental and theoretical B(E2)s as a function of angular momentum

The B(E2) value for the 4_1^+ level in ^{132}Te is somewhat lower than the theoretical estimates. This discrepancy for a single level could not be understood by even lowering the effective charges to the Bohr Mottelson value (e_p =1.0, e_n =0.65). Similar discrepancies with shell model and experimental data for 4_1^+ level is found in ^{136}Te which lies symmetrically on the other side of N = 82 shell closure of ^{132}Sn. A systematics comparing the experimental reduced transition probability B(E2) as function of neutron number for Te isotope has been shown in Fig 2 & it has been observed that the measured B(E2) values in the present work are well in agreement with the global trend of nonlinearly decreasing B(E2) with increasing neutron number in Te isotopes around ^{132}Sn.

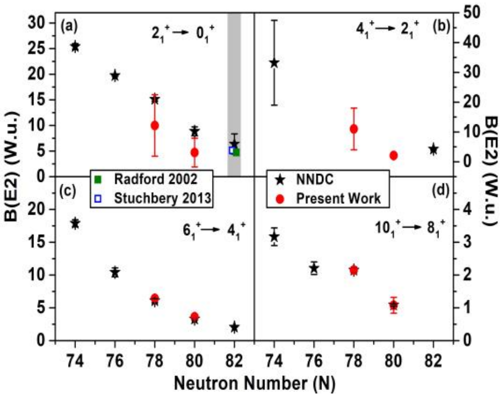

Fig 2: B(E2)s as a function of neutron Number

The details of the measurements, new results & its interpretation will be presented.

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