Probing Low-spin Collectivity of A∼60 Nuclei using DSAM with Inelastic Scattering

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Introduction

The development and evolution of collectivity with changing number of nucleons between the shell closures have been of sustained interest in nuclear structure pursuits. The efforts in this context are typically pursued through measurement of the B(E2) values, known to be quantifying the deformation/collectivity, and have been carried out for the low-spin states of the nuclei of interest. Such endeavours in the Sn (Z = 50) [1, 2] and the Te (Z = 52) [3] isotopes, for instance, have led to intriguing observations on the associated shapes as well as the resulting structure characteristics. In another region of the nuclear chart, the A∼60 nuclei around and between the doubly-magic ^{56}Ni- (Z = 28, N = 28) and ^{78}Ni-core (N = 50) have been recently probed with similar objectives. The measurement of B(E2)($2_1^+ \rightarrow 0_1^+$) and B(E2)($4_1^+ \rightarrow 2_1^+$) of ^{74,76}Zn, recently reported by Illana *et al.* [4], vis-a-vis the results for other isotopes, has indicated shape evolution and shape coexistence in some of the systems. The experimental results of such measurements are often interpreted in the framework of (Monte Carlo) shell model calculations that facilitate microscopic understanding of the underlying structure and excitations. The nuclei closer to the ^{56}Ni-core, such as ^{62,63}Ni [5], were earlier observed to exhibit collective behaviour in the low-spin regime. The odd-A Cu (Z = 29) isotopes, ^{67,69,71,73}Cu, had been investigated for B(E2)($1/2_1^- \rightarrow 3/2_1^-$), B(E2)($5/2_1^- \rightarrow 3/2_1^-$) and B(E2)($7/2_1^- \rightarrow 3/2_1^-$) transition probabilities by Stefanescu *et al.* [6] and were reported with increased collectivity for the $1/2^-$ and the $7/2^-$ states of the aforesaid isotopes that span the semi-magic closure at N = 40. There are also recent theoretical calculations [7] indicative of wobbling excitations in the Ni-isotopes, thus hinting at the development of triaxiality therein. In the light of such varied experimental and theoretical revelations, it might be an interesting proposition to undertake systematic study of the collectivity associated with the low spin states of nuclei around the closure at Z, N = 28. The same could be implemented through measurement of nuclear level lifetimes that translate into transition probabilities with stringent dependence on the microscopic build of the levels and thus facilitates a conclusive understanding of their characteristics. The present work is part of a proposed programme for lifetime measurements of low-lying states of stable nuclei in the A∼60 region, using the Doppler Shape Attenuation Method (DSAM). The first of such measurements have been carried out for the $1/2_1^-$, $5/2_1^-$ and $7/2^-$ states of ^{63,65}Cu and the same is reported herein.

Experiment and Data Analysis

The low-spin excited states of interest in ^{63,65}Cu nuclei were populated using ^{63,65}Cu(^{32}S,^{32}S')^{63,65}Cu* inelastic scattering at E_{lab} = 88 MeV. The beam was delivered by the 14 UD Pelletron LINAC Facilty (PLF) at TIFR, Mumbai. The target was self-supporting foil of natural Cu of thickness 8.9 mg/cm^2. The γ-rays from the de-exciting nuclei were detected using an array of Compton suppressed HPGe clover detectors at TIFR. During the experiment, the array consisted of 18 detectors positioned at 157^o (3), 140^o (3),

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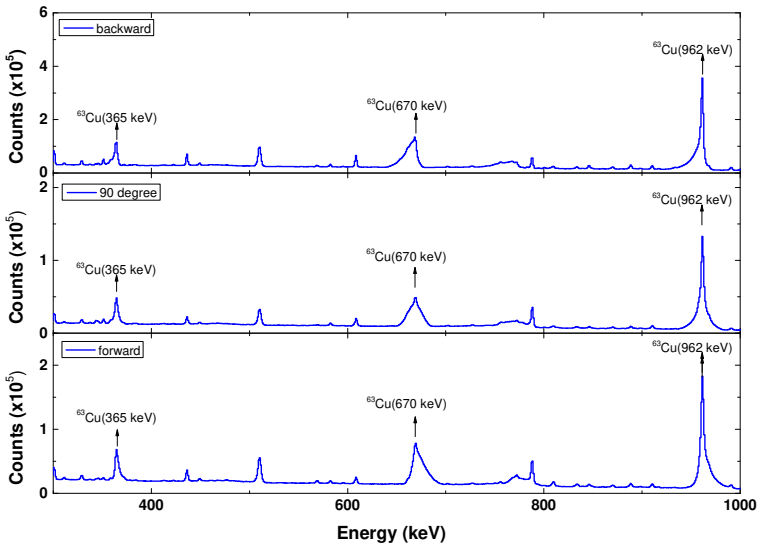

FIG. 1: Doppler shapes observed on the γ-ray peaks corresponding to $7/2^- \rightarrow 5/2^-$ (365 keV), $1/2^- \rightarrow 3/2^-$ (670 keV) and $5/2^- \rightarrow 3/2^-$ (962 keV) transitions in ^{63}Cu, in the present experiment.

115^o (3), 90^o (4), 65^o (2) and 40^o (3). The pulse processing and data acqusition system was based on 12-bit 100 MHz PIXIE-16 digitizers (XIA LLC) running on the TIDES [8] software. Data were acquired under the trigger condition of detector multiplicity ≥ 1 (singles). The acquired data were sorted into addback spectra corresponding to different angles using MARCOS [9] and will be analyzed for the respective level lifetimes.

Preliminary Observations

Fig. 1 illustrates the Doppler shapes observed on different transitions in ^{63}Cu, in the present measurement. These are being analyzed for the respective lifetimes using the updated methodologies [11] of DSAM as developed at the UGC-DAE CSR, Kolkata Centre. The same has facilitated in expanding the applicability of DSAM beyond the use of fusion-evaporation reaction and elemental stopping media. The details of the exercise shall be presented in the Symposium.

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