Study of deformed structures in N ~ Z nuclei

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Introduction

Nuclei which belong to the interface of the *sd-pf* shells especially the *N ~ Z* nuclei are of contemporary interest. Their structures is expected to reveal "collective phenomena" and these nuclei nuclei belong to the transient region where the nuclear deformation is not well defined and is changing from prolate to oblate. [1,2] The structure of these nuclei could be investigated within the framework of large basis shell model calculations involving the *fp* shells, whose occupation would favour deformed structures.

From this view-point ^{29}Si, ^{41}Ca would be ideal candidates to investigate the aforementioned features. To the best of our knowledge the present work is the first ever detailed heavy-ion induced in-beam spectroscopic investigation of ^{29}Si.

Experimental details

The ^{16}O + ^{18}O reaction at an incident energy of 34 MeV was used to populate the high spin structures in ^{29}Si. The ^{16}O beam was provided by the 15 UD Pelletron facility at the IUAC, and the INGA was used to detect the de-exciting gamma rays. During the experiment a part of the beam was incident on the Al frame and the ^{16}O + ^{27}Al reaction resulted in the population of the nuclei such as ^{38}Ar, ^{41}Ca to name a few. The power of INGA provided us with sufficient statistics on these nuclei so as to undertake a detailed investigation of their level structure. The use of INGA is optimized for such investigation primarily due to (i) the enhanced detection efficiency for $E_\gamma > 1$ MeV, and we expect the level structure of these nuclei to be dominated by such high energy gamma transitions ; (ii) the detectors were placed at 148^o, 123^o, 90^o, 57^o and 32^o *w.r.t* the beam axis. This not only allowed us to obtain the lifetime of the levels using the conventional DSAM, but allowed us to identify fully shifted transitions in a consistent and conclusive manner.

The data was sorted using the IUCSORT and RADWARE software, using the conventional angle dependent E_γ-E_γ matrices. Since the level lifetime of most of the levels of interest is less than the stopping time in the Ta backing, stopped component of the corresponding transition peaks were not observed. The angle dependent matrices were used to identify the fully shifted transitions. Fig.I depicts the situation for the 3157 keV transition belonging to ^{29}Si.

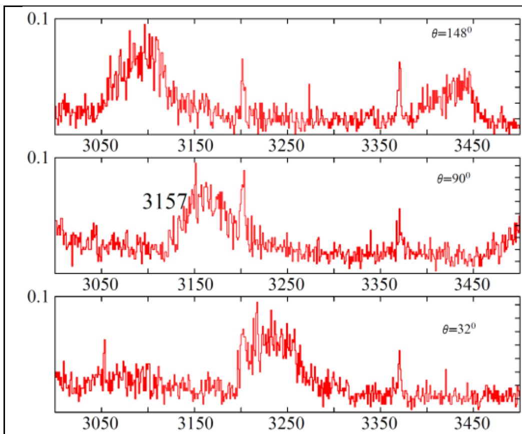

Fig.I. Representative angle dependent gated spectra

The analysis of such angle dependent gated spectra helped us identify the transitions originating from the decay of levels with extremely short times in these nuclei. The observed angular co-relations and the linear polarization measurements were used to obtain a consistent information on the spin-parity of the levels Fig.II presents the level scheme for ^{29}Si as deduced from the present study.

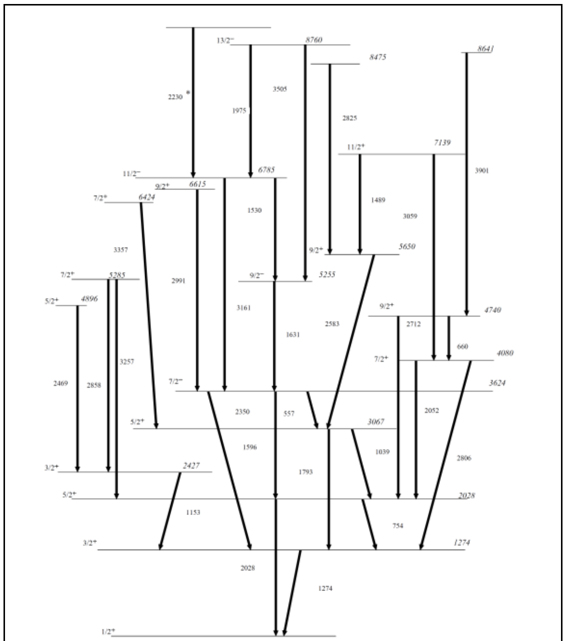

FiG. II Level scheme for ^{29}Si as deduced from the present investigations.

Attention is drawn to the 3624 keV level, the first negative parity state which de-excites to the positive parity "*sd*" states via the 1596 and 557 keV transitions. The linear polarization measurements for these transition indicated that the 1596 keV is a mixed transition. Similar transitions have been the focus of several investigations in the neighbouring nuclei [3]. The observation of mixed multipolarity for these transition is indicative of the fact that the wave-function for this negative parity level has contributions from several configurations. The detailed large basis shell model calculations are in progress to interpret the observed level structure.

A crucial test of the wave-function is provided by the level lifetime. We have observed Doppler shapes : both broadened due to de-excitation during the slowing down of the recoils, as well as completely shifted originating from the decay of fast transitions before the recoils commence their slowing down. These lineshapes are being analyzed to extract the level lifetimes [3]. A representative Doppler shape is presented in Fig.III.

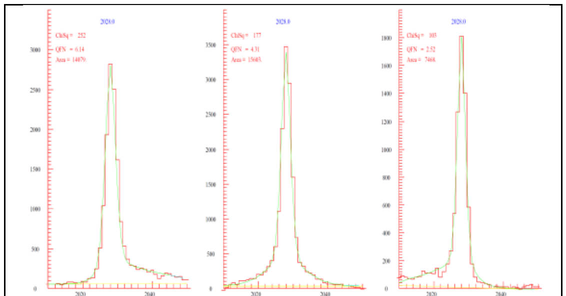

Fig.III. Representative lineshape for 2028 keV transition in ^{29}Si.

The present lifetimes would be compared with the earlier reported values and would help us constrain the calculations, thereby providing us with an insight into the underlying microscopic configurations.

As mentioned earlier we have also substantial information on the level structures of N ~ Z nuclei such as ^{38}Ar, ^{41}Ca to name a few. The presence of fast transitions (completed shifted) in these nuclei, are indicative of the occurrence of deformed structures in these nuclei. An interesting observation was the occurrence of a doublet 1390 keV transition in ^{41}Ca. One of the transitions originates from the decay of a very short level as seen from the observed shifts in the angle dependant data, where as the other 1390 keV transitions indicates a predominant Doppler shape. This preliminary observation may be attributed to the occurrence of a highly deformed structure in ^{41}Ca.

References

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