Multi particle excitations in ^{102}Cd

S. Sihotra[1],* M. Singh[1], V. Singh[1], N. Singh[1],
S. Saha[2], J. Sethi[2], R. Palit[2], and D. Mehta[1]
[1]*Department of Physics, Panjab University, Chandigarh-160014 and*
[2]*Department of Nuclear and Atomic Physics, TIFR, Mumbai-400005*

Introduction

The structure of nuclei belonging to A∼100 mass region are interesting to study because of the dominating shell closure effects. In nearly spherical nuclei, regular rotation-like bands indicate a unusual type of collectivity, wherein a few correlated high-j valence particle and hole states become available for alignment that generates the high angular momentum states. Pictorially, the alignment of the valance particles and holes looks like closing of a shears, hence the term "shears mechanism" was coined by R. M. Clark and A. O. Macchiavelli [1, 2] to depict this type of excitations. Shears mechanism is prevalent in the nuclei in mass ∼ 100 region due to presence of the valance particles and holes near N = 50 shell closure. In these cases, the total angular momentum can be represented as vectorial sum of the individual valance proton hole (particle) and neutron particle (hole) angular momentum. The even-even transitional nucleus ^{102}Cd with 48 protons and 54 neutrons is close to the doubly magic ^{100}Sn with N=Z=50. Its structure may follow the shell model or it may possibly develop collective features since it has sufficiently large number of valence nucleons outside the ^{100}Sn core. The protons and neutrons occupy high angular momentum orbits like $\pi g_{9/2}$ and $\nu(g_{7/2}, h_{11/2})$. The properties of the high spin states should present the competition and interplay of both types of particles. Typical multiplet of states at intermediate spins appear to rise from this competition between proton holes and neutron particles observed in earlier in-beam gamma ray studies on ^{102}Cd [3, 4]. The distinct pattern of proton and neutron excitations at low spins may align to contribute to the total angular momentum at high spin giving rise to magnetic rotation. However, the lack of firm spin parity assignment and absolute transition strengths, the interpretation of high spin states in ^{102}Cd is very tentative [3, 4]. This mechanism is characterised by a pronounced decrease in magnetic dipole transition strength B(M1) as the shears vectors close. Such behaviour may be proved from lifetime measurements.

*Electronic address: ssihotra@pu.ac.in

Experimental Details

Excited states in the ^{102}Cd nucleus were populated in the $^{75}As(^{31}P, 2p3n)^{102}Cd$ fusion evaporation reaction at E_{lab}= 125 MeV. The de-excitations were investigated through in-beam gamma-ray spectroscopic techniques. The ^{31}P beam was provided by the Pelletron-LINAC facility at TIFR, Mumbai. The ^{75}As target of thickness 2.8 mg/cm^2 was prepared by vacuum evaporation and rolled onto a 10 mg/cm^2 thick Pb backing. The recoiling nuclei in the excited states were stopped within the target and the de-exciting gamma-rays were detected using the Indian National Gamma Array (INGA) consisting of 21 Compton suppressed clover detectors. Two and higher fold clover coincidence events were recorded in a fast digital data aquisition system based on Pixie-16 modules of XIA LLC [5]. The data sorting routine Multi pARameter time stamped based COincidence Search program (MARCOS)", developed at TIFR, sorts the time stamped data to generate E_γ-E_γ matrices and E_γ-E_γ-E_γ cubes compatible with Radware format. These data were analysed using RADWARE software package [6] to develop the level scheme.

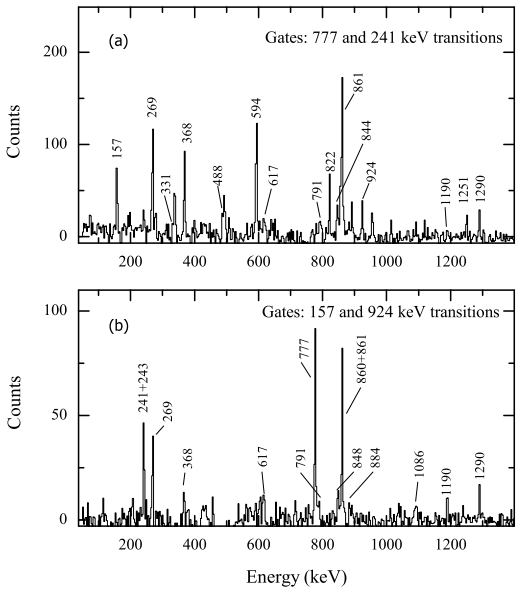

FIG. 1: The γ-ray coincidence specta with double gate on (a) 777 keV and 241 keV transitions, and (b) 157 and 924 keV transitions, respectively

Discussion

The present level scheme of ^{102}Cd is built on the I = 0^+ ground state band B1 along with three side bands B2, B3 and B4 [3]. In the earlier level scheme, many of the linking transitions were unobserved and tentatively placed [3, 4]. In the present measurements, such transitions have been placed and bands extended considerably. Some new transitions have also been observed linking the B1, B2, B3 and B4 bands while many more to extend these bands up to spin of 21^+, 19^+,23^- and 24^+ respectively. The gated coincidence specta are ^{102}Cd is given in Fig. 1.

The M1 character of the transitions in the spin range 10^+-14^+ in ground state band are interpreted as stretched magnetic transitions (shear mode) showing magnetic rotation in ^{102}Cd [3]. We would like to extend the shear mode to higher spin after extracting lifetimes and multipole character of the transitions from the angular distribution data on ^{102}Cd. The structure of ^{102}Cd nucleus is comparable to that of ^{104}Cd, whereby the magnetic rotation has been observed in the spin range 10^+-15^+. The two structures resemble most probably due to the coupling of $g_{9/2}$ holes to the $d_{5/2}$ and $g_{7/2}$ neutrons. However, the structure of ^{104}Cd has more regular appearance than ^{102}Cd which may be due to the increased number of positive parity neutrons.

Acknowledgments

Authors acknowledge the joint effort of IUAC, New Delhi, TIFR, Mumbai, and IUC-DAEF and SINP, Kolkata, in establishing the INGA clover array. Thanks to the pelletron staff for smooth functioning of the accelerator.

References

[1] Clark R M and Macchiavelli A O 2001 *Nucl. Phys.* A **682** 415c
[2] Macchiavelli A O *et al* 1998 *Phys. Rev.* C **58** R621
[3] K. P. Lieb *et al.*, Phys. Rev. C **63**,054304 (2001).
[4] J. Persson *et al.*, Nucl. Phys. A **627**, 101 (1997).
[5] R. palit *et al.*, Nucl. Instr. Meth. A **90**, 680 (2012).
[6] D. C. Radford, Nucl. Instr. Meth. A **361**, 297 (1995).