Structure of odd-odd nuclei in A $\sim$ 110 region

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Introduction

Shapes play decisive roles on the spectra of excitations in the nucleus. In A $\sim$ 110 region of the nuclear landscape, the nuclei have proton holes in the high-Ω orbitals and neutron particles in the low-Ω orbitals. The ground states of these nuclei exhibit a variety of shapes ranging from weakly deformed to triaxial [1]. Therefore, nuclei in this region provide a good testing ground for the investigation of the rare excitation modes like magnetic, antimagnetic and chiral rotations, characteristic of weakly deformed or near-spherical and triaxial nuclear shapes, respectively. Relativistic Mean Field calculations predict some of the odd-odd isotopes of Rh, Ag and In in this mass region to have multiple chiral bands owing to their triaxial shapes [2].

The prime objective of the thesis is to provide new measurements in the odd-odd nuclei in the A $\sim$ 110 region near the Z=50 shell closure, namely, ^{108}Ag and ^{112}In, to search for the signatures of chiral, magnetic and antimagnetic rotational bands in these isotopes. The excited states of ^{108}Ag and ^{112}In nuclei were populated in the heavy-ion fusion-evaporation reactions listed below.

- ^{100}Mo(^{11}B, 3nγ)^{108}Ag at 39 MeV
- ^{94}Zr(^{18}O, p3nγ)^{108}Ag at 72 MeV
- ^{100}Mo(^{16}O, p3nγ)^{112}In at 80 MeV

The emitted γ-rays from the excited states were studied using the Indian National Gamma Array (INGA). Results from the detailed spectroscopic and lifetimes measurements were carried for ^{108}Ag and ^{112}In are presented.

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Results and discussion : ^{108}Ag

Level structure of ^{108}Ag was extended substantially with addition of 65 new transitions. Spins and parities of most of the transitions were measured. A few level lifetimes were also measured. The level scheme is classified in three structures according to the physics interpretations, namely, a pair of negative parity degenerate bands, two positive parity bands and the low-lying states near the isomer.

The pair of nearly degenerate negative parity dipole bands was observed with similar level energies, spins and parities. The various observables of the twin bands, like level energies, ratios of the transition strengths, have been compared to the Triaxial Projected Shell Model (TPSM) calculated values. The axial and triaxial deformation parameters values, $\epsilon = 0.225$ and $\epsilon' = 0.09$ in the TPSM calculations provide a better agreement with the experimental results. The amplitudes of the wave functions of both the bands were analyzed, which have been observed to have contributions from different quasi-particle configurations for the yrast and the partner bands, which suggest that these bands are based on different quasi-particle structures [3].

In the positive parity part of the level scheme of ^{108}Ag, two dipole bands have been investigated. The lifetime measurements for one of the positive parity bands in ^{108}Ag were performed. The magnetic dipole transition strengths (B(M1) values) for this band were deduced from the measured level lifetimes. The variations of the experimental B(M1) with spin show a decreasing trend with increasing spin. A four quasi-particle $\pi g_{9/2} \otimes \nu(h_{11/2})^2(g_{7/2})$ configuration with the deformation parameters $\epsilon = 0.170$, and γ value in the range of $0°$ to $6°$ were used in the Tilted Axis Cranking (TAC) calculations. This indicated the presence of magnetic rotation phenomenon in this nucleus. Also, a new dipole band has been identified, which is confirmed to have positive parity. Based on the TAC calculations, $\pi g_{9/2} \otimes \nu(h_{11/2})^2(g_{7/2})$ configuration has been assigned to this band.

The low-lying states of ^{108}Ag near the $I^\pi = 6^+$ isomer have been studied thoroughly. Present work suggests a total of three possible transitions at energies below 420 keV from the isomeric state to the higher intermediate excited levels, whose subsequent decay can branch to the ground state bypassing the isomer. Multipolarity of most of the states have been established with the angular correlation measurements which aid an improved estimation of the cross section for induced isomer depletion via these states. The relative intensities of the low-lying γ-rays, branching ratios and I^π assignments of the levels from the experimental data have been used in estimating the integral cross sections of the possible depletion paths [4].

Results and discussion: ^{112}In

High spin structure of ^{112}In was studied. The excited levels have been observed up to 8.3 MeV excitation energy and spin $\sim 25\hbar$. The level scheme has been classified into three dipole bands and one quadrupole band. Angular correlations and polarization measurements were performed to firmly assign their spins and parities. Level lifetimes of three bands were measured using the Doppler shift attenuation method. Transition strengths were obtained for three bands, namely, the two dipole bands and one quadrupole band from the measured level lifetimes.

The extracted B(M1) values of the positive parity dipole band have a decreasing trend with increasing spin. Tilted axis cranking calculations based on the $\pi g_{9/2} \otimes \nu(d_{5/2}/g_{7/2})(h_{11/2})^2$ configuration reproduce the measured trend of B(M1) with increasing spin. This establishes the phenomenon of magnetic rotation in ^{112}In for the positive parity dipole band. The TAC calculations based on $\pi g_{9/2} \otimes \nu(h_{11/2})^3$ quasi-particle configurations have been compared with the measurements for band C. The fair agreement of TAC calculations with the measurement suggests a weak prolate deformation for the positive and negative parity dipole bands for ^{112}In [5], contrary to the triaxial deformation predicted in the RMF calculation [2].

Polarization and lifetime measurements of the transitions were carried out for the quadrupole band, which was predicted to be an anti-magnetic rotational band based on the theoretical calculations. The polarization measurements for the transitions decaying from the band head of $\Delta I = 2$ band, established its negative parity. The B(E2) values deduced from the lifetime measurements show a decreasing trend with increasing spin. The extracted B(E2) values and rotational frequency has been compared with the calculation based on semiclassical model of twin shear bands. The $\Im^{(2)}$/B(E2) values for this are higher than the normal and super deformed bands which suggests a possible presence of anti-magnetic rotation phenomenon in this nuclei for the first time.

Acknowledgments

I extend sincere gratitude to my advisor, Prof. R. Palit, for his guidance and support. I thank Prof. J.A. Sheikh, Dr. G. H. Bhat, Prof. J. J. Carroll, Prof. P. M. Walker, Dr. S. Kumar, and Dr. Z. Naik for a fruitful collaboration. I would like to acknowledge all the members of DNAP, accelerator staff at TIFR and IUAC, and the INGA collaboration.

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