Investigation of Magnetic and Antimagnetic Bands in Nuclei

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Introduction

Investigation of nuclei near closed shell, having few valance nucleons outside the magic-core, is the subject of interest of this thesis. The near closed shell nuclei are important for the testing of various theoretical models as they exhibit several processes to generate the high angular momentum associated with a variety of nuclear structural phenomena. The systematic structural investigation of these nuclei are also important to understand the shape evolution. The near closed shell nuclei mainly from A $\approx$ 110 and 140 region have been a subject of interest for both experimental as well as theoretical investigations. The presence of few valence proton holes (at high-Ω $g_{9/2}$ orbital) and neutron particles (at low or mid-Ω $g_{7/2}$, $d_{5/2}$, $h_{11/2}$ orbital) near Fermi surface is expected to play a significant role for magnetic and antimagnetic rotations and hence have been investigated. The nuclei around A $\approx$ 140 region, with Z = 64 and N = 82 also enriched with various structural phenomena like magnetic and antimagnetic rotations, octupole deformation, γ-vibration, high spin super-deformation and also non-collective excitations.

Experiment and Analysis

There were two sets of experiment which were carried out to populate the nuclei of these two different mass regions. The excited states of ^{104}Pd were populated via ^{94}Zr(^{13}C,3n) fusion-evaporation reaction at beam energy of 55 MeV. Another experiment was carried out to populate ^{145}Eu and ^{145}Gd via ^{122}Sn(^{28}Si,p4n and 5n) fusion-evaporation reaction at 146 MeV beam energy. The beams were provided by 15-UD Pelletron accelerator at the Inter University Accelerator Centre (IUAC), New Delhi and the γ-rays were detected by HPGe Clover detectors of INGA (Indian National Gamma Array) [1], for both experiments. Low energy photon detectors were also used to detect the low energy γ-rays in the second experiment. Adequate amount of two and higher fold γ-events were collected in list mode. A CAMAC based analog data acquisition system, namely CANDLE, was employed to record the valid events. To analysis of the coincidence data, a standard gating procedure was carried out with the help of the INGASort and RADWARE [2, 3] software. To measure the lifetime of the excited states the computer code LINESHAPE [4] was used.

Results and Discussions

In the present work mainly closed shell nuclei like ^{104}Pd, ^{145}Eu and ^{145}Gd were experimentally investigated.

^{104}P*d:* To study the effect of the valance proton hole and neutron particle near Z/N=50 closed shell of A$\approx$ 100 region, ^{104}Pd is one of the good choice among the Pd isotopes. The antimagnetic rotational band has been found in ^{106}Cd isotone and most of the neighbouring Cadmium nuclei. The lifetime of the excited states after alignment of positive parity yrast band have been revised via Doppler Shift Attenuation Method (DSAM) and a low quadrupole moment was found, which support the formation of AMR band. The transition rates and the deformation is similar that was reported earlier. Lifetime of seven excited states belonging to two negative parity side-bands have also been determined and

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found a moderate quadrupole deformation of the states has been found [5].

^{145}G*d:* Being a closed shell nuclei with a valance neutron hole, the decay structure of this nucleus is quite complicated. Most of the transitions are non-collective and they decay from single particle or core coupled excited states. The spin, parity, intensity, multipolarity mixing of several states have been deduced and level scheme is effectively updated above 3.5 MeV. The transitions are mostly non-collective and decays from single particle excited states. The collective states have been observed above 8.7 MeV excitation. The spin and parity of the states of the band have been determined and it has been seen that the dynamic moment of inertia of the quadrupole band is constant, which is a indication of AMR band which is possible for the nucleus having a few valance proton and neutron near closed shell. However, the lifetime measurement is necessary to determine the B(E2) range of the transitions.

^{145}E*u:* The level scheme of the closed shell nucleus ^{145}Eu has been updated significantly with the detail spectroscopic information. Most of the tentative or not assigned spin, parity of the excited states above 6 MeV have been confirmed by determining the directional correlation of oriented states, angular distribution of oriented nuclei, polarization asymmetry and multipolarity admixture of dipole/quadrupole measurements.

Semiclassical Model Calculation

Semiclassical Model Calculations have been carried out for the investigation of the yrast bands of ^{109,111}Cd and ^{102}Ru and the possibility of antimagnetic rotational (AMR) band was explained.

^{109,111}C*d:* The investigation was carried out for the ^{109,111}Cd nuclei via Semiclassical model and the mechanism of the yrast band has been discussed. The generation of the antimagnetic rotational band in ^{109,111}Cd is explained via shears mechanism. The choice of parameters for ^{109,111}Cd isotopes and their effects on the shear angle and B(E2) have also been described. For ^{109}Cd, the theoretical results are matched with the experimental one and for ^{111}Cd a prediction has been made for antimagnetic rotational band [6].

^{102}R*u:* Semiclassical model calculations have been carried out for the ground-state band of ^{102}Ru for finding the possibility of antimagnetic rotational structure with more than two pair of proton holes in A $\approx$ 110 region. The experimental dynamic moment of inertia of the yrast band in the spin range of 14^+ to 24^+ is constant and also in the range of antimagnetic rotational bands. The model calculated decreasing trend of B(E2) with angular momentum and sharply increasing trend of $\Im^{(2)}$/B(E2) indicates the antimagnetic nature of the band with higher number of proton holes. Reasonable agreements between the experiment and the calculation of spin vs. angular frequency support the adequacy of the parameters and the configuration used for the calculation [7].

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