## List of Figures

1.1 Decreasing trend of $B(M1)$ values for the MR bands ......................... 5
1.2 The atomic nuclei, in mass $\sim$ 100 region, show antimagnetic rotational bands . 6

2.1 Single particle and collective excitations ........................................ 13
2.2 Alignment of the nucleons ....................................................... 15
2.3 Rotation and Deformed Coupling ............................................. 16
2.4 Alignment of the nucleons ....................................................... 17
2.5 Observation of the dipole band ............................................... 23
2.6 Rotational spectrum in superdeformed nucleus ............................... 24
2.7 TAC calculations in Pb isotopes ............................................... 25
2.8 Schematic diagrams of the shears mechanism ................................ 27
2.9 Orientation of the hole and the particle angular momentum vectors ....... 28
2.10 Coupling scheme of the magnetic rotation ................................... 29
2.11 Schematic diagrams of the shears mechanism with the principal axis cranking . 31
2.12 Comparison of the experimental results with the SPAC model calculations .... 32
2.13 Comparison of the experimental $B(E2)$ values with the calculations ........ 34
2.14 Comparison of the experimental $J^{(2)}/B(E2)$ values ..................... 35

3.1 Schematic diagram of the fusion evaporation reaction ....................... 41
3.2 Decay of the compound nucleus ................................................. 42
3.3 Gamma ray crosssection .......................................................... 45
3.4 Schematic diagram of a clover detector ........................................ 46
3.5 Indian National Gamma Array at TIFR ........................................ 48
3.6 Block diagram for the digital DAQ ............................................. 50
3.7 Construction of the level scheme .............................................. 57
3.8 Angular distribution of the $\gamma$ rays ....................................... 59
3.9 Construction of the level scheme .............................................. 61
3.10 Directional Correlation of the $\gamma$ rays .................................. 62
3.11 Geometry of Compton polarimeter .......................................... 66
3.12 Technique of the Doppler shift attenuation method ......................... 72
3.13 Schematic diagram of the decay scheme .................................... 74
3.14 Schematic diagram for side feeding of the levels ........................... 76
3.15 Configuration of the clover detector ........................................ 78
3.16 Construction of the time difference spectrum .......................... 79
3.17 Linear fit of the time difference spectrum ................................ 80
4.1 Indian National Gamma Array at TIFR .................................... 85
4.2 PACE4 statistical model calculations ........................................ 86
4.3 The gain matching procedures ................................................. 90
4.4 Addback factor of a clover detector ......................................... 91
4.5 Efficiency of the clover detector ............................................. 92
4.6 Population of the residual nuclei ............................................. 93
4.7 The width of the substate population ($\sigma/I$) of the reaction .......... 93
4.8 Asymmetry correction factor $a(E_\gamma)$ for 90° clover detectors ..... 95
4.9 Polarization sensitivity of the 90° clover detectors .................. 95
4.10 Partial level schemes .......................................................... 96
4.11 Line shapes obtained from full clover and a single crystal data .... 97
4.12 Percentage of deviation of the lifetime results ......................... 99
5.1 Shape coexistence in $^{186}$Pb ................................................. 102
5.2 Partial level scheme of $^{142}$Sm ............................................. 105
5.3 Proposed level scheme of $^{142}$Sm ......................................... 107
5.4 Angular distribution measurements for the transitions ............... 113
5.5 Summed double gated spectra showing the transitions of the quadrupole structures I, II and III ........................................... 115
5.6 Summed double gated spectra showing the transitions of the dipole structure IV .......................................................... 116
5.7 Summed double gated spectra showing the transitions of structure V .......................................................... 117
5.8 Estimation of the nuclear level lifetime of 7⁻ isomeric state from the time-difference spectra ............................................. 120
5.9 Estimation of the nuclear level lifetime of an isomeric state from the time-difference spectra ............................................. 120
5.10 Lineshape fitting for the transitions in the dipole band IV in $^{142}$Sm .......................................................... 122
5.11 Lineshape fitting for the transitions in the quadrupole bands I and III in $^{142}$Sm .......................................................... 123
5.12 Shell model calculations for the low lying states ....................... 126
5.13 Experimental $B(M1)$ values for the dipole band IV in $^{142}$Sm .......................................................... 127
5.14 Schematic description of the shears structure for the dipole band IV in $^{142}$Sm .......................................................... 128
5.15 Comparison of the SPAC model calculations for the dipole band IV in $^{142}$Sm .......................................................... 129
5.16 PES calculations for the quadrupole bands in $^{142}$Sm ............... 131
5.17 Single particle routhians for protons and neutrons .................... 133
5.18 Excitation energies of the quadrupole bands I, II and III in $^{142}$Sm relative to the rotating liquid-drop energy ............................................. 134
5.19 Potential Energy Surface calculations ..................................... 135
5.20 Comparison of the experimental and the calculated (CNS) $B(E2)$ values for the quadrupole bands I and III in $^{142}$Sm .......................................................... 136
6.1 Measured electric quadrupole transition rates ......................... 143
6.2 The schematic diagram of time reversed orbits at bandhead .......... 144
6.3 Partial level scheme of $^{143}$Eu ........................................ 148
6.4 Summed double gated spectra for the dipole structures .................. 151
6.5 Parallel and Perpendicular scattering of the transitions .................. 152
6.6 Summed double gated spectra for the dipole bands DB I & DB II ........... 153
6.7 The partial level scheme of the dipole structure in $^{143}$Eu .................. 154
6.8 Line shapes for the transitions in the dipole band DB I in $^{143}$Eu .......... 155
6.9 Experimental $B(M1)$ values for the DB I and the DB II in $^{143}$Eu .......... 157
6.10 Experimental $B(M1)$ values for the DB1 and the DB2 in $^{141}$Eu ............ 158
6.11 Total rothian surface calculations for the dipole bands DB I and DB II in $^{143}$Eu 159
6.12 The energy and angle from the SPAC calculations ........................ 160
6.13 The comparison of experimental results with the SPAC model calculations . . 161
6.14 Double gated spectrum for the quadrupole structure in $^{143}$Eu ............ 162
6.15 The partial level scheme of the quadrupole structure in $^{143}$Eu. .......... 164
6.16 Parallel and Perpendicular scattering of the $E1$ transitions ................ 165
6.17 Variation of $P$ against $R_{DCO}$ for the $E1$ transitions among with the 803.9 keV transition ......................................................... 166
6.18 Energy of the quadrupole structures I & II in $^{143}$Eu ........................ 168
6.19 Align angular momentum ...................................................... 168
6.20 Lineshpe of the $\gamma$-ray transitions of the quadrupole structures I and II in $^{143}$Eu 170
6.21 Comparison of the experimental results with the semi-classical model ........ 172
6.22 Plot of the $J^{(2)}/B(E2)$ ratios for the quadrupole structures ............... 173
6.23 The evolution of the shears angle over the entire AMR bands ............... 174