CHAPTER VIII
Summary and Conclusions

The statistical theory incorporating deformation, collective and noncollective rotational degrees of freedom, shell effects are used to study the shape-phase transitions and shape evolution in rapidly rotating nuclei.

Structural changes with temperature and angular momentum in high spin hot nuclear systems in the light nuclei region (s-d shell), medium mass nuclei $40 \leq A \leq 60$ and rare earth regions $120 \leq A \leq 164$ are discussed. The nuclear properties considered in the study are nuclear level density, level density parameter, spin cut-off parameter, rotational energy, back shift energy and effective moment of inertia. Shape transitions from prolate collective to oblate noncollective are found to occur in nuclei $^{136}$Sm, $^{138}$Sm, $^{140}$Sm and $^{142}$Sm around the angular momentum $M = 50h$. Neutron emission from fused compound systems at high spins for these nuclei is also analysed. An increase in neutron emission is predicted due to an abrupt decrease in neutron separation energy around the angular momentum $M = 50h$. Since the decrease in separation energy is closely associated with the structural changes in the rotating nucleus, relative increase in neutron emission probability density around certain values of angular momentum may be construed as an evidence for the shape transitions. The rotational energy and effective moment of inertia are found to increase sharply for particular angular momentum states of the nucleus due to shape transition from prolate to oblate or spherical to oblate.
The nuclear level density extracted for $^{36}$Cl, $^{51}$V, $^{118}$Sn and $^{163}$Dy nuclei is found to agree well with the experimental data. The spin cut-off parameter which is one of the essential parameters in evaluating the nuclear level density has been extracted for about 3175 isotopes of the elements by four different methods and their results are compared.

In this thesis, a clear picture of shape transition and shape coexistence in superdeformed nuclei is provided concerning the interpretation of superdeformed structures where more than one equilibrium shape plays a dominant role. In addition, the general features of superdeformed bands in all the mass regions are outlined. The dynamical moment of inertia calculations performed using a microscopic approach is in good agreement with the experimental predictions.

Investigations on the temperature, angular momentum and deformation parameters dependence of pair gap, specific heat, level density are made for some of the 2s-1d shell light nuclei mainly with respect to their ability to describe the phase transition. The occurrence of a peak structure in the specific heat at temperatures of the order of 2.0–3.0 MeV confirms the phase transitions for seven even–even 2s–1d shell nuclei. The results are discussed with the inclusion of fluctuations. Among them, the influence of statistical fluctuation that washes out the collapse of pairing correlation has been investigated in detail. The effect of washing out of the pairing-phase transition and smoothening of shape-phase transition due to fluctuations in pair gap and deformation are clearly demonstrated. For all the nuclei considered, the effect of washing out the sharp phase transition from superfluid to normal driven by temperature is obvious and so we
conclude that there is no true phase transition and this may be due to the finiteness of space involved in the calculation.