SUMMARY AND CONCLUSIONS

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THEORETICAL STUDIES OF NUCLEAR STRUCTURE
IN VIEW OF EXOTIC NUCLEAR DECAYS

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SUMMARY AND CONCLUSIONS

The present thesis is an attempt to understand more on the exotic decay, the rare mode of decay intermediate between $\alpha$ emission and spontaneous fission. The common feature of this decay is that one of the nuclei always refers to spherically closed or nearly closed shell nucleus. The so far observed daughter nuclei in the exotic decay of naturally occurring radioactive nuclei are spherically closed shell $^{208}$Pb or neighbouring nuclei. The only other nucleus experimentally searched for is $^{100}$Sn daughter, in the exotic decay of $^{114}$Ba produced in heavy ion reaction.

Chapter 2 gives a brief description of QMFT and the existing theoretical models, which are broadly classified as the fission model and the cluster model. Details of the present model are also given in this chapter, which is based on the potential barrier consisting of the Coulomb potential and the proximity potential. It is found that inclusion of proximity potential reduces the height of the barrier, which closely agrees with the experiments.

In chapter 3 the present model is applied to different cases of experimentally observed decay modes. It is found that the present model is able to reproduce the
experimental half lives and branching ratios reasonably well. In chapter 4 the exotic decay of neutron deficient Xe to Gd parents in trans-tin region emitting $^4$He to $^{32}$S was studied. Most of the decay half lives are well within the present upper limit for measurements. $T_{1/2}$ value is minimum for those decays leading to $^{100}$Sn daughter which stress the role of doubly magic $^{100}$Sn daughter in these decays. It is found that neutron excess in the parent nuclei slow down the exotic decay process. Geiger-Nuttall plots for all clusters from these parents are studied and are found to be linear. It is found that inclusion of proximity potential will not produce any deviation to the linear nature of these plots. Nuclear structure effects and shell effects are evident from the observed variation in slope and intercept of Geiger-Nuttall plots.

Exotic decay of neutron rich Ba to Gd parents emitting various clusters are also studied. In this case also it is found that $T_{1/2}$ has minimum value for those decays leading to doubly magic $^{132}$Sn daughter compared with the neighbouring ones. This finding also reveals the role of doubly magic daughter in exotic decay. It is found that neutron proton asymmetry in parent and daughter is responsible for the reduced decay rate of these nuclei compared with their neutron deficient counterparts. The preference of non $\alpha$ like structures in the decay leading to $^{132}$Sn and $\alpha$ like structure in the decay leading to $^{100}$Sn point out the importance of asymmetry and symmetry of proton and neutron in the two cases respectively.
In chapter 5 we have modified the present model and made an attempt to study the effect of deformation $\beta_2$ and $\beta_4$ of parent and daughter on half life time, treating emitted cluster as spherical. When deformation effects are included half life time value is found to decrease and it is found that parent deformation alone will not produce any appreciable change. These findings are in gross agreement with the experiments.

We studied the fine structure (decay to the excited state of daughter) for some modes of decay and calculated the hindrance factor for $^{14}$C transition from $^{223}$Ra to various excited states of $^{209}$Pb. The details are described in chapter 6. It is found that the transition to ground state is strongly hindered, while the one to first excited state is favoured. The transitions to second and third excited states are also hindered. Our findings are in good agreement with the experimental data. The fine structure from $^{223}$Ra gives direct evidence on the presence of spherical component in the deformed parent nucleus.

Cluster formation probabilities are calculated within the fission model for 8 heavy nuclei and studied its variation with $A_2$, the mass of the emitted cluster. These are described in chapter 7. It is found that the cluster formation probability decreases with $A_2$ up to a value 20 and then increases and remains almost a constant. From the observed variation we conclude that the transition from cluster mode to fission mode take place at $A_2=20$ in exotic decay process.
Exotic decay of superdeformed $^{76}$Sr, $^{78}$Sr and $^{80}$Sr nuclei in the ground state and formed in heavy ion reactions are studied in chapter 8. Our study shows that in the ground state these nuclei are stable against exotic decay. When these nuclei are formed as an excited compound system, depending on the excitation energy $T_{1/2}$ value decreases considerably and the nuclei become unstable against decay.

In the last chapter we studied the exotic decay of 11 heavy nuclei with $(Z \geq 100)$, which can be produced in heavy ion "cold fusion" reaction. Our study reveals that exotic decay of these heavy systems lead to the production of some other new heavy and super heavy nuclei as daughter.