Nuclear reaction and Structure effects near and beyond the β-stability line

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The atomic nucleus is a strongly attracting, many body quantum mechanical system, which exhibit various shapes and excitation modes. Many theories and experiments have been employed to explore the behavior of nuclear systems. From last few decades, the advancements in experimental techniques have enriched the knowledge related to new exotic phenomenons like extension in dripline, one or two neutron/proton halo, neutron skin and bubble effect in density profile, vanishing of shell closer effect and existence of new magicity *etc.* The comparison of nuclear properties between stable and unstable nuclear systems have been provide better insight of such exotic nuclei.

In the present thesis, I intended to explore reaction and structure effects of nuclear systems from $\beta-$ stability line to drip line region in consideration of above discussed issues. In this regard, the well known Glauber approach [1] is used to investigate the reaction dynamics, whereas structural properties of nuclei are estimated by two different mean field formalisms *i.e.* relativistic mean field [2] and non-relativistic mean field [3]. The main advantage of mean field formalisms is the deduction of bulk properties of nuclei by self consistent manner. The bulk properties like binding energy, root mean square matter and charge radius, quadrupole deformation, nucleon separation energy, single particle energy, nucleonic density distribution of light mass to medium mass nuclei are studied using above formalisms.

In the first part of the thesis, I have studied bulk properties of various isotopes of Be to Ar nuclei using both relativistic and non-relativistic mean field formalisms [4]. As the bulk properties of nuclei depend on the choice of force parameters in mean filed formalisms. So the parameters NLSH, NL3/NL3* in RMF and SLy4, SkI4 in HF approaches are used on some test cases for the evaluation of the bulk properties. Another choice of the bosonic and the fermionic model space is also important for the estimation of bulk properties of exotic nuclei in mean field formalisms. The scrutinizing of the optimal limit has been tested through the variation of $N_F = N_B$ from 6 to 20 for the test cases of ^{36}Si isotopes. The rest calculations of all set of nuclei are taken care by this choice of fermionic and bosonic model space and selected parameters sets. The predicted results are also compared with the experimental data. The comparison between the calculated values and available experimental data suggests that both the formalisms are capable to reproduce bulk properties to a reasonable extent. Whereas comparative look of our study suggest that the RMF shows superiority over the non-relativistic mean field approach. One can also conclude from this analysis that, the accuracy of the predicting power of RMF gets enhanced with an increase of mass number of nuclei. The role of BCS pairing is another factor which may contribute to enhance the accuracy of bulk properties of unstable nuclei. Hence the effect of BCS pairing is also studied for isotopes of Ne, Mg and Si nuclei[4]. The density distribution of nuclear system is extremely important for the reaction dynamics and related structure analysis. Hence density distributions of Be-Ar isotopes have been analysed in the frame-work of the mean field formalisms. The Depletion factor of these densities are also examined and bubble effect for ^{22}O, ^{23}F, ^{34}Si, ^{36}S, ^{36}Ar and ^{46}Ar nuclei in

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light mass region is studied and the prominent cases showing bubble effects are identified as ^{22}O, ^{23}F, ^{34}Si and ^{46}Ar [4]. Such effect is of huge relevance for studying the nuclear structure in the drip-line and the superheavy mass region.

In second part of the thesis, we have extended our study through reaction cross sections of light mass nuclei using Glauber model with densities from relativistic and non-relativistic mean field formalisms. In first step the densities are converted in the form of Gaussian coefficients for the order of 2 and 4 Gaussian using RMF and HF densities before feeding in Glauber model. The sensitivity of converted densities has been checked with the RMF and HF densities in terms of their density profiles and the estimated values of reaction cross sections. The fittings appear better with 2-Gaussian form for RMF as compared to the 4-Gaussian form, whereas a reverse trend is observed for the non-relativistic mean field densities. The comparative analysis suggests that both the formalisms are competent with a relative edge for RMF densities over non-relativistic mean field formalism. The deformation or deformed structure of nuclei is expected to affect the reaction dynamics, so an effort is made to address such effect in the context of dynamical evolution of the nuclear systems [4]. The role of deformations is analyzed through deformed densities by carrying out a comparative analysis using spherical densities of same set of nuclei. Structure effect on the reaction cross sections are also analyzed by considering variable target projectile combinations.

We have further extended our research for some of the halo nuclei *i.e.* ^{6}He, ^{11}Li, ^{11}Be, ^{15}C, ^{19}C, ^{22}C, ^{23}O and ^{31}Ne [4]. The estimated values of bulk properties are compared with the available experimental data. The densities obtained from two completely different sources have been used in the extended Glauber model (GMMB) for an evaluation of σ_R over the energy range. The results obtained from both the RMF and Hartree-Fock formalisms are well compared with the experimental data with an edge for the simple effective interaction (SEI-I). A systematic study of the Glauber formalism has been used for the investigation of the structure/shape of ^{31}Ne halo candidate. An analysis of the reaction cross section and one neutron removal cross section based on our study also support the halo status of ^{31}Ne nucleus.

Further, in reference to a newly discovered halo nucleus of ^{37}Mg, we have compared the ground state properties of Mg isotopes with RMF formalism and also studied the reaction cross sections of these isotopes taken as projectile from the valley of stability to drip line region at E_{proj}=240 MeV/nucleon. We observed a nice agreement of estimated ground state properties using RMF densities with the experimental data, except the case of ^{37}Mg. The systematic variation of skin effect parameter is used in order to see the effect on density profile and reaction cross sections. A study of an angular elastic differential cross section for $^{34-38}$Mg and further a investigation with Glauber two body calculation also supports the halo status of ^{37}Mg [4].

Acknowledgments

I am very much thankful to Prof. S. K. Patra and Prof. Manoj K. Sharma for their guidance and moral support for completion of this task.

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