Structure of drip-line and superheavy nuclei in effective relativistic and non-relativistic interactions

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The synthesis and the properties of superheavy and drip-line nuclei are interesting and crucial research topics in nuclear physics. The main objective to study the superheavy element (SHE) is their stability and their decay properties. On the other hand, the exotic nuclei (*near drip-line*) show some special features like magicity, **Island of Inversion**, halo and clustering, which are the main innovative subjects for the present research [1]. Both these nuclei contribute fundamental knowledge about the nuclear interactions, potentials, shape, single-particle energies, radial nucleonic distribution, spin, isospin and the magnetic moments. The work of last 50 years by various nuclear physicists in these fields have not yield a complete success yet. Following are some of the obvious problems which needed immediate attention both in the drip-line and superheavy valley. In the last four years of my research, I have addressed some of the points which are given below:

- What is the maximum number of elements that can co-exist either in nature or can synthesized in laboratory ?
- Where is the border line of the nuclear chart i.e. the proton and neutron drip-lines ?
- What is the life time of the newly synthesized superheavy elements?
- What are the next shell closures for proton and neutron after ^{208}Pb i.e the next double magic nuclei ?
- Whether the conventional magic numbers till valid for nuclei far away from the stability ?
- What about the **Island of Inversion** (abnormal single-particle level) at various mass region of the nuclear chart ?

To answer these questions, first we have to understand the fundamental reagents, which are responsible for the existence of these nuclei against Coulomb repulsion or repulsive component of nuclear force. At present, it is well known that the effective interactions such as non-relativistic Skyrme-Hartree-Fock (SHF), simple effective interaction (SEI), Gogny and relativistic mean field (RMF) formalisms are quite success in this regards. These models not only reproduce well the experimental observables near the stability line, but also predict remarkably well away from the stability line and in the valley of superheavy regions. Here, we have used as well as developed the SHF, SEI and RMF formalisms to explain the properties of some specific exotic nuclei.

First of all, a microscopic origin nucleon-nucleon (NN) interaction (entitled as *R3Y*-potential) potential is derived from the popular relativistic-mean-field Lagrangian. The derived interaction is related to the inbuilt fundamental parameters (mass and coupling constants) of RMF theory. The obtained results for the NN-potential with different forces are compared with the well-known phenomenological M3Y effective NN-interaction. Further, we applied the microscopic origin NN-potential to the exotic cluster radioactive decays and scattering to determine the applicability [2].

In superheavy mass region, we applied these formalisms to calculate the ground state properties of Z= 115, 117, 120 and 122 isotopes from proton to neutron drip-lines. The shape of the ground and intrinsic excited states and

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other related observables are analyzed for various force parameters. The α-decay properties like decay energy and half-life these atomic nucleus are also studied. The results obtained from our calculations compared with other theoretical models and experimental data [3–6]. Moreover, an extensive theoretical search for the proton magic number in the superheavy valley beyond Z=82 and N=126 is carried out. For this we scanned a wide range of elements Z = 112-126 and their isotopes using spherical RMF and SHF models for various force parameters. Based on the calculated observables like pairing gap Δ_q, two nucleon separation energy S_{2q}, pairing energy E_{pair} and the shell correction energy E_{shell}, we predict Z =120 as the next proton magic and N=182/184 as the subsequent neutron magic numbers [7].

In medium mass nuclei we study the clustering structure (nuclear sub-structure) of Ba isotopes in an axially deformed cylindrical co-ordinate. The clustering configurations inside the nucleus determined from the total (neutrons-plus-protons) density distributions for various shapes of both the ground and excited states. The important step, carried out here for the first time, is the counting of number of protons and neutrons present in the clustering region(s). Presence of ^{12}C along with other lighter clusters such as ^{2}H, ^{3}H and nuclei in the neighborhood of $N = Z$ are the constitutes clusters in prolate-deformed ground-states of $^{112-116}$Ba and oblate-deformed first excited states of $^{118-122}$Ba nuclei [8]. All these results are of interest for the observed intermediate-mass fragments and fusion-fission processes. Again , this calculation is an important information for unobserved evaporation residues. The work also further extended to the lighter mass region of the nuclear landscape [9].

Some effort directed towards the study of neck structure in neutron rich *Th* and *U* isotopes. The main objective of this study is to find a good source for nuclear fuel. The calculation includes the evolution of neck, neck constituents and their ratios. The ratio determines the fission characteristics i.e the nucleons come out in the prefission stage can used in the post-fission [10].

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