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R-process Nuclei in the Rare-earth Region above N=126 in Relativistic Hartree Bogoliubov theory: A Preponderance of Shape-coexistence in Nuclei

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Abstract.

I will discuss the shell structure of nuclei beyond $N = 126$ relevant to the third peak at $A \sim 195$ in r-process nuclear abundances [1]. A comparative study of nuclei near the r-process path is made in three different Lagrangian models NL-SV1 [2], SVI-2 [3] and NL3 [4] within the framework of the relativistic Hartree-Bogoliubov theory. Ground-state properties of even-even nuclei in isotopic chains with $Z = 58 - 72$ in the highly neutron-rich region are investigated. A comparison of binding energies with mass formulas shows that the RMF model SVI-2 without self-interaction of σ and ω mesons exhibitsyes an excellent agreement with the mass formula HFB-24 [5] especially in the extreme region of the r-process path. Thus, SVI-2 has a potential to become an alternative to mass formulas.

It is shown that in all the above Lagrangian models, in the neutron rich region between the shell closures $N = 126$ and $N = 184$, there is a preponderance of nuclides exhibiting coexistence of well-deformed prolate and oblate shapes in the ground state. A prolate ground state is shown to evolve smoothly to a coexisting oblate ground state via a near degeneracy with successive addition of neutrons. Induced by an onset of deformation for $N \geq 130$, nuclei approaching the r-process path are shown to exhibit enhanced stability in many isotopic chains ($Z > 60$). This has the effect of shifting the expected neutron drip line significantly farther into the neutron-rich region especially for the higher Z chains. Consequences of the enhanced stability, the shape co-existence and degeneracy of shapes in nuclei on the r-process nucleosynthesis will be discussed.

References

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