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Study of Giant Monopole Resonance for super heavy nuclei $Z = 113$ using relativistic mean field formalism

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Introduction

The Giant Monopole Resonance (GMR) is a principle source of information on the coefficient of incompressibility K of finite nuclei and nuclear matter. Incompressibility of the finite nuclei have interesting relations with nuclear matter properties which play very important role in nuclear physics community. By study of giant monopole resonance, one can deduce the incompressibility of the system. Giant monopole resonances are collective nuclear vibrations which provide a unique laboratory setting to probe the bulk properties of the nuclear force. One of the isoscalar compressional modes the isoscalar giant monopole resonance (ISGMR) is useful in constraining the equation of state (EoS) of nuclear matter. For example, the nuclear incompressibility K, is a fundamental quantity in the EoS and is directly correlated with the energies of the ISGMR in finite nuclei.

Super Heavy Nuclei (SHN) which are on the stability line, but unstable due to excessive coulomb repulsion, attract attention to the highly asymmetric nuclear matter. SHN are vulnerable and unstable in nature because in the presence of excess of neutron and proton. In this paper we calculate the Giant monopole resonance by taking Relativistics mean field formalism(RMF) with NL3 parameter set. Although, the NL1 parameterset has been cosidered for a long time to be one of the best interactions to predict the experimental observables , but the discovery of NL3 Parameterset gives complements the imitations of the NL1 Force and compute the Ground state properties of finite nuclei. we select NL3 parameter for our further study of Giant Monopole Resonance energy and other related quantities.

Methods

Here we derive the expression for Giant Monopole Resonance (GMR) by using scaling method in RMF Formalism and this work elaborated by using Relativistic Thomas-Fermi [2]. The Relativistic Thomas–Fermi (RTF) with scaling and constraint approaches in the framework of nonlinear $\sigma - \omega$ model. The RTF is the $\hbar^2$ correction to the RTF, where variation of density takes care mostly in the surface of the nucleus. The RTF formalism is more towards the quantal Hartree approximation. It is also verified that the semi classical approximation like Thomas–Fermi method is very useful in the calculation of collective property of nucleus, like giant monopole resonance(GMR). Within the last three years one has obtained more and more evidence on the excitation of a giant monopole resonance in the inelastic scattering of various particles on nuclei. (For references see the review presented by F.E. Bertrand at this Summer School.) The importance of this mode of excitation of the nucleus lies in the fact that its frequency is related to the compressibility of nuclear matter. We briefly discuss

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here the problems encountered when one attempts to extract the value of the compressibility of nuclear matter from the observed frequency of the giant monopole resonance (the so-called breathing model) Although, the scaling method is not new, the present technique was developed first by S. K. Patra et. al. citesnp and not much has been explored for various region of the Periodic Table. Thus, it is interesting to apply the model for Super Heavy Nuclei (SHN) and calculation be explore at $Z = 113$. The scaling energy as E_s as

$$E_s = \sqrt{C_m/B_m}$$

where C_m is restoring force of the monopole vibration and B_m is mass parameter of monopole oscillations [4]. The constraint energy E_c given as,

$$E_c = \sqrt{AK^c A/B_m^c}$$

where A is atomic number, $K^c A$ constraint compressibility modulus and B_m^c is the constraint mass parameter [5].

TABLE I:

N	Es	Ec	ΔE
165	13.2	12.5	0.8
169	13.1	12.4	0.7
170	13.1	12.4	0.7
171	13.1	12.4	0.7
172	13.0	12.4	0.7
173	13.0	12.4	0.6
174	13.0	12.4	0.6
177	12.9	12.4	0.6

Results

We calculated the Giant Monopole Resonance energy using both the scaling and constraints method in the Frame work of RTF (Relativistics Thomas Fermi) using NL3 Parameter for Super Heavy Element Z=113 [3]. Our obtained results are given in figure 1 and

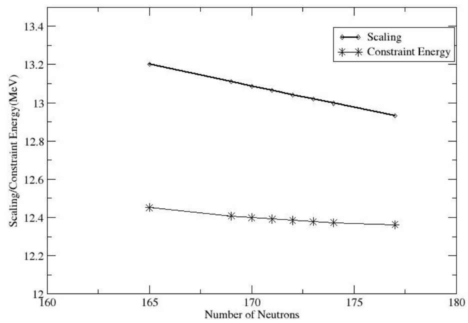

FIG. 1: The results of scaling energy and constrained energy with NL3 parameter set are shown for Nihonium (Z=113) elements.

table 1. It is clear that when we increases the number of neutrons then scaling energy E_s and constrained energy E_c monotonously decreases but rate of change of scaling energy is more than rate of change in constraint energy with neutron number. In this calculations energy difference in scaling and constraint GMR energy ($\Delta E = E_s - E_c$) is less than 1 MeV. In the figure diamonds represents scaling energy and stars represents constrained energy. As shown in the figure the value of ($\Delta E = E_s - E_c$) decreases in isotopic series. In future we will study Giant monopole resonance of some more exotic super heavy elements.

References

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