Giant monopole moment in relativistic mean field formalism

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Introduction

The giant monopole resonance (GMR) is a principal source of information on the coefficient of incompressibility of nuclei and nuclear matter [1]. Nuclei undergo oscillation about the equilibrium point in this mode. It is a small amplitude collective motion wherein the nucleus participates as a whole. The nuclear matter equation of state, i.e. the coefficient of incompressibility $K\infty$ is a key quantity in nuclear physics, because it is related to many properties of nuclei (such as radii, masses and giant resonances). One important source of information on the coefficient of incompressibility is provided by the study of the giant monopole resonance (GMR) in finite nuclei [2]. The nuclear matter coefficient of incompressibility is not a measurable quantity; what is measured is, actually, the energy of the GMR of finite nuclei [2].

Method

Here we derive analytical expression for giant monopole resonance by using scaling method in a relativistic mean field formalism [2]. The semiclassical ground state densities and meson fields are obtained by solving the Euler-Lagrange equations coupled to the field equations [3]. Our calculations of GMR in relativistic mean field framework have relied on the scaling method [3]. Denoting by λ the collective coordinate associated with the monopole vibration, a normalized scaled version of the baryon density is $\rho_\lambda(r) = \lambda^3\rho(\lambda r)$.

Accordingly, the local Fermi momentum, the meson fields are also modified by scaling with their respective scale densities. After operating the method, the energy density H changes to $\mathcal{H}_\lambda$. Then the restoring force $C_M = \partial^2/\partial\lambda^2[\int d(\lambda r)H_\lambda(r)d\lambda^3] \,|_{\lambda=1}$ is calculated. Similarly we obtain the mass parameter and finally the excitation energy of monopole state E_M defined as:

$$E_M = \sqrt{\frac{\hbar^2 K_A}{M < r^2 >}}, \qquad (1)$$

where $< r^2 >$ is the rms radius, K_A is the coefficient of incompressibility and M is the nucleon mass.

Results

We calculated the giant monopole resonance (GMR) using the $\sigma-\omega-$interaction term in the relativistic mean field (RMF) formalism. The SIG-OM parameter set of Ref. [4] is used our calculations. The physical quantities like root mean square proton, neutron, charge and matter radius (r_p, r_n, r_c and r_m) for Ca isotopes are evaluated as a representative case. Then we computed the monopole excitation energy of Ca-isotopes starting from the neutron-deficient to neutron-rich region. The results are shown in Fig. 1. In addition to this we have also icomputed the coefficient of incompressibility for finite nuclei using both scaling and constrained calculations, which is shown in Fig1 (c). The difference in excitation energy obtained from scaling E_s and constrained E_c is the width of the monopole spectra defined as $\sigma = E_s - E_c$ is also shown in Fig.1(b).

In summary, we computed the monopole excitation energy E_s and E_c using scaling and constrained formalism. The coefficient of incompressibility coefficient K_A are calculated in the Ca-isotopic chain. The related quanti-

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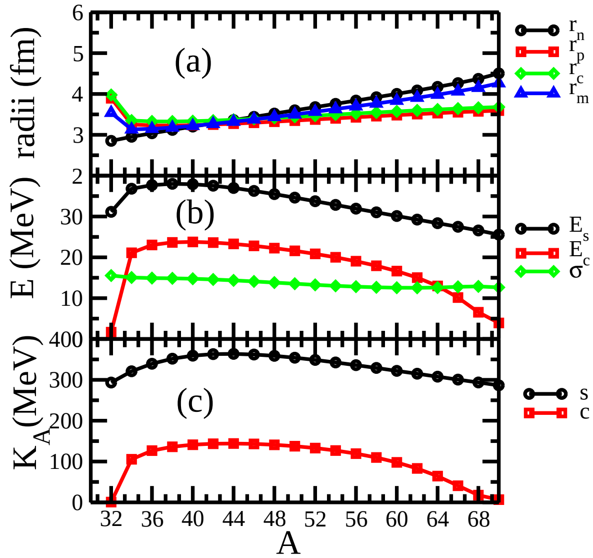

FIG. 1: The results obtained with relativistic mean field formalism using SIG-OM parameter set are shown. (a) is for rms radii for proton r_p, neutron r_n, charge r_c and matter distribution r_m, (b) is for monopole excitation energy obtained from scaling and constrained calculation and (c) is the coefficient of incompressibility for Ca isotopes within scaling and constrained calculations.

ties like, proton, neutron and matter radii are also estimated.

References

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