STRUCTURAL PROPERTIES OF FINITE AND INFINITE NUCLEAR SYSTEMS AND RELATED PHENOMENA.

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Introduction

The nuclear structure provides a platform to understand the basic nature of the nucleon-nucleon interaction, which has remained question since the birth of nuclear physics. Many theory has been put forwarded to understand the nature of nucleon-nucleon force, but still, it is partially understood. In this thesis we studied the structure of both finite and infinite nuclear matter, using relativistic mean field theory. A special focus has given to super-heavy and drip-line region, which is considered as a venerable area of nuclear physics in the current year. The magic combination of proton and neutron are discussed in the super heavy region. We extended our investigation to collective excitation like isoscalar giant monopole resonance (ISGMR) and isovector giant dipole resonance (IVGDR). ISGMR state also known as the breathing mode of the nucleus. Excitation energy of the ISGMR gives a direct way to calculate the finite nuclear incompressibility (K_A) and consequently the infinite nuclear matter incompressibility(K_∞), which plays an important role in understanding the equation of state (EOS) of a neutron star. We have presented a thorough investigation of excitation energy of ISGMR in super heavy and drip-line nuclei. Collective excitation in medium-heavy nuclei also play a crucial role to understand nuclear structure. The softness of Sn isotopes is discussed with the help of relativistic Thomas-Fermi (RTF) and relativistic extended Thomas-Fermi (RETF) formalism.

Another most important things are the nucleon-nucleon interaction to understand the nuclear structure. In the present thesis, we have studied N-N interaction from the effective relativistic mean field interaction (RMF). Patra et al. have proposed a new R3Y interaction, which based on the effective RMF interaction to study various properties of finite and infinite nuclear matter. In the last part of my thesis is dedicated to the structure of neutron star, which is a real example of the infinite nuclear matter. We have calculated the equation of state for the neutron star and this EOS used as the inputs for the TOV equation to calculate the mass and radius of the neutron star.

Formalism

RMF is the basic formalism, which is used throughout the thesis. According to the RMF theory, nucleons are interact with each other through the exchange of various effective meson like σ, ω, ρ and δ-meson. The strength of the meson-nucleon interaction are adjusted in order to reproduce various properties of finite and infinite nuclear matter. Begin relativistic in nature it provides a unique way to calculate both finite and infinite nuclear matter properties. Some additional methods are used in a particular case , like calculation of the excitation of giant monopole resonance, N-N interaction, S-factor calculation, and mass radius of a neutron star. In order study the excitation energy of giant monopole resonance, we have used the scaling and constraint calculation. Detail about the formalism can be found [2]. To obtain an effective nucleon-nucleon interaction we have used the procedure devel-

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oped by Patra et al.[1]. The astrophysical S-factor is calculated for the proton-rich nuclei using Talys code[4]. EOSs for the neutron star are calculated using RMF formalism and the mass-radius profiles are calculate with help of Tolman-Oppenhemier-Volkoff (TOV) equation.

Result and Discussion

We have predicted that Z=126 and N=182/184 can be considered as the next magic combination of proton and neutron in super heavy-region, using SEI and RMF formalism. Our prediction based on the various signature of the magic combination like S_{2n}-energy, gaps in the single particle levels etc. Excitation energy of ISGMR is discussed for both drip-line and super heavy region. The mass dependence of the excitation energy also discussed. Not only in the super heavy region excitation energy of ISGMR in the medium heavy region ($A \sim 100$) also plays a crucial role to understand nuclear structure. The softness of Sn isotopes is discussed in our formalism. We found that the experimental excitation energy of Sn isotopes can be reproduced if we consider the value of K_∞ lies in 210-230 MeV[5]. The effects of self-interaction of ω-meson (ω^4) are discussed. It is clearly shown that ω^4 interaction has notable effects on the EOS and finite nuclear properties like giant monopole resonance. ω^4 interaction gives an extra weak attractive force in the short range part of nucleon-nucleon interaction. Effects of the non-linearity of σ- meson on the calculation of astrophysical S-factor is also discussed in the present thesis. Last part of the thesis, we discussed the structure of infinite nuclear matter, like neutron star. The effects of the δ-meson on mass-radius profile of hyperon and pure neutron star are analyzed. Both static and rotating condition are discussed. We found the effect of the δ-meson on the hyperon star is relatively more than on neutron star for both static and rotating case.

1. Conclusion

In summary, we studied the structure of both finite and infinite nuclear matter using RMF theory. We focused mainly on the :

1. Magic combination of proton and neutron in super heavy region.
2. Excitation energy of ISGMR.
3. Softness of Sn isotopes.
4. Nucleon-nucleon interaction.
5. Effects of nonlinear σ interaction on the astrophysical S-factor.
6. Effects of δ-meson the mass and radius hyperon and the neutron star.

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