Study on the Energy Gap and Symmetric Energy Coefficient of Atomic Nucleus and Shell

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Abstract: As one of the basic properties of nuclei, nuclear mass (binding energy) has always been an important research topic in nuclear physics. For the calculation and preoccupation of unknown nuclear mass, more mass-related terms need to be explored through nuclear mass formula. The density dependence of nuclear symmetry energy is uncertain near the saturation density of nuclear matter. The relativistic mean field theory is used to describe the interaction between nuclei, and the influence of the symmetry energy of the nucleus on the density range, the lattice phase structure and the phase transition density of the nucleus of the neutron star is studied, and the possible correlations are explored. On the one hand, this paper studies the nuclear energy gap of the nucleus based on the WS4 nuclear mass model and another different Global quality model system. For unknown neutron-rich and overweight regions, the nuclear quality predicted by these different models varies widely.

1. Introduction

As one of the basic chemical properties of the nucleus, nuclear mass (binding energy) has always been an important research topic in nuclear physics [1]. It plays a very important role in the calculation of nuclear structure and reaction. In addition, the understanding of the origin of elements in the universe is also crucial [2]. Single-particle motion is related to the shape of the nucleus, and the movement of the entire nucleus is highly collective. It is experimentally observed that some nuclei have large quadrupole moments, indicating that these nuclei may have ellipsoidal changes, which is determined by observing the structure and properties of the rotating zone. A large number of identical electrons always have a certain spacing in the arrangement of space. If each atom is regarded as a free electron, then the electronic configuration and corresponding energy levels in the isolated atom are the same [3]. Other experimental results and related theoretical studies also show that, in addition to an approximate mean field, the pair force is the main residual interaction, which may even lead to the rearrangement of the nucleon filling order [4]. For most of the rotational spectra of deformed nuclei, we can describe them very well by means of the axisymmetric and reflective symmetric deformed potential field. The determination of nuclear mass is inseparable from the accurate calculation of nuclear shell correction. Systematic study of nuclear properties and observable quantities related to shell correction is necessary for the verification and further improvement of nuclear mass model.

2. Bright Gap of Nucleus

The shape of anisotropic nuclei is described by intrinsic polar moments and deformation parameters. In many applications, the shape of the nucleus can be expanded by a multipolar spherical harmonic function, and the radius of the surface of the nucleus can be defined by a standard deformation parameter:

$$\omega(E)_i = \frac{E_i}{\sum_{j-1}^{n}\left(E_j / n\right)} \tag{1}$$

Nuclear separation energy is not only closely related to droplet lines of particles, but also

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provides important information about shell effect and neutron-rich core-shell evolution in magic numbers, especially in overweight regions. We will systematically study the law of the shell energy gap based on the WS4 model and six different "global" mass models from the neutron neutron separation energy. The neutron neutron separation can be expressed as the difference between the binding energies:

$$S_{2n}(N,Z) = B(N,Z) - B(N-2,Z) \tag{2}$$

The crystalline solid should be an insulator and has no electrical conductivity. However, when the crystalline solid contains impurity atoms, the appearance of these impurities becomes a direct cause of the conduction of the crystalline solid. For example, the damage caused by the silicon atomic nucleus radiation to the crystalline solid is another source of free electrons generated in the crystalline solid. The nuclear-shell gap includes the neutron-shell gap and the proton-shell gap, which directly reflects the abrupt behavior of the Two-neutron separation energy and the two-proton separation energy at the magic number.

$$\Delta(N,Z) = \Delta_{\mathrm{n}}(N,Z) + \Delta_{p}(N,Z) \tag{3}$$

The distribution of energy storage electrons is diverse, and the positions of energy storage electrons and holes in the energy gap are related to the energy stored in them, including their specific positions in the energy gap, the width of the energy gap formed by the crystal structure and the type of radiation [5]. In reflectively asymmetric odd-A nuclei with large deformations, there exist parity double bands. These rotational bands have the same spin but opposite parity, and their energy levels are nearly degenerate. And the corresponding density when the isomer begins to appear, the corresponding density and the degree of softening when the nuclear state equation begins to soften depends not only on the temperature, the coincidence constant but also on the isospin asymmetry of the baryon material. When the baryon number density is low, the most stable phase is the droplet. When the value of the symmetry slope parameter is small, other non-spherical nuclei will appear in sequence as nb increases [6]. In addition, the proton separation energy is more deviating than the neutron separation energy, especially the WS series model, which means that some of the proton-related physical mechanisms in these quality models need further research.

In order to investigate the magic number in the overweight region, we not only discuss the possible position of magic number from the angle of shell gap, but also compare it with the nuclear shell correction calculated by nuclear mass model. By changing the radius of the primordial cell, we find the radius that minimizes the energy density in the primordial cell, so as to determine the most stable state of the system at that density. Thus, the phase with the lowest energy density is found, and at the same time, it is compared with the homogeneous substance to determine the X-phase structure and the phase transition property of the shell core. The expression of the symmetry energy of the nucleus is:

$$\ln\left(\frac{X}{X_0}\right) = \mu_X \cdot t \tag{4}$$

In the formula, X0 is an isospin asymmetry parameter. The slope parameter qt of the symmetry energy at the saturation density μx of the nuclear matter versus the number of baryons can be written as:

$$q_t = \frac{(C_0 - C_t)*V}{m} \tag{5}$$

Studies have found that these nuclei may present a psychic structure. Therefore, a reasonable interpretation of the possible new "magic number" has become a new challenge in the theory of nuclear structure. At the same time, it should be compared with the homogeneous matter to determine whether the core-nuclear phase transition occurs, that is, whether the uniform material energy is lower than the phase energy. There is a finite high potential energy barrier between the two mirror minima. The shape of the nucleus can reach its mirror shape through this barrier, which represents the instability of the octapole deformation of the nucleus, which is experimentally observed. The reason for the splitting of the parity [7]. Radiation photoluminescence is due to the ionization of neutral atoms in crystalline solids caused by nuclear radiation, which excites electrons to the conduction band, thus forming ions, holes and positive ion vacancies in the lattice, or ion pairs, electrons and negative ion vacancies. The moving electrons in the conduction band are captured by neutral atoms or clusters. The calculated results of nuclear deformation correspond with those of shell gap. That is to say, for light nuclei and medium-mass nuclei, the nuclei with large shell gap are basically spherical, especially the spherical neutron-rich nuclei predicted by 24O, 46Si and 52Ca need further confirmation.

3. Symmetric Energy Coefficients of Nuclei

The study of symmetric energy of asymmetric nuclear matter is one of the hot topics in the field of nuclear matter in recent years. It not only affects the properties of neutron-rich nuclei and drip-line nuclei, but also plays an important role in the dynamics of heavy ion reactions. Before the shell-core phase transition occurs, only droplet phase exists, and other aspherical phases do not appear in the inner shell. From this we can see that in the inner shell of neutron stars, smaller parameters may lead to more complex pasta phases and a larger density range. For most of the deformed nuclei, it can be considered that their intrinsic shape is relatively stable. If the mechanical element matrix element is used, the deformation of the intrinsic shape is selected instead of the spherical base, which will bring great convenience. . The energy release of the stored energy can be spontaneous or it can release the stored energy during the excitation process after receiving the external energy. By studying the symmetry energy coefficient of the nucleus with the number of nucleons and the deformation law, the quality of the drip core can be described more accurately, which is helpful for further improvement and verification of the nuclear quality model, and also for the symmetry of nuclear matter. Research provides more information.

Ignoring Coulomb energy and microcosmic shell effect, the average energy per nucleon in droplet model can be expressed as follows:

$$\tilde{E} / A \approx (E_{tot} - E_c) / A \tag{6}$$

Under the Skyrme energy density functional and the skillful Thomas Fermi approximation framework (ETF2), the macroscopic partial energy of the nucleus can be obtained as the average energy per nucleus:

$$\tilde{E} / A = E_{Sky} / A \tag{7}$$

The above discussion does not consider the case of nuclear deformation. Whether the nucleation deformation affects the symmetry energy coefficient of the nucleus is a problem worth studying. Similar to the case of a spherical core, we calculated the average per nucleon energy for a series of different quadrupole changes. The energy gap should have been a forbidden band, that is, electrons are prohibited from appearing in this area. Therefore, the classical conductive theory is only conductors and insulators, either conductive or non-conductive. The long-range interaction between the nucleons in the nucleus is equivalent to the mean field, and the nucleus performs an approximately independent motion in this averaging field. Due to some symmetry, the single-particle level has a cluster phenomenon, that is, the energy level is unevenly distributed, and some Shell structure. In addition, the weakening of the shell can be observed in the isogram of the binuclear gap and the shell correction energy. This makes the super heavy core of the magic number combination not necessarily a double magic nucleus. The expression of the volume energy term is more accurate, which can correctly describe the main part of the nuclear binding energy. The relative error of the coefficient of symmetric energy term is large, that is to say, the symmetric energy term can not fully describe the symmetric energy part of the system, mainly because the author has less information about the symmetric energy.

In order to better understand the deformation dependence of symmetric energy coefficients, we also studied the effect of surface dispersion. This series of nuclei disperse on the surface of the sphere. The empty circle and the real circle represent proton dispersion and neutron dispersion respectively. We can see that the isospin dependence of surface dispersion is obvious. Our results also show that the effective mass of nucleons and DEHA matter depends on the isospin asymmetry of matter. If a more accurate solution is required, the space required is huge, and the calculation is very difficult. Many configuration energy configurations that are not important in the ground state or low-excited state are taken into consideration, making the calculation very It is cumbersome, but it ignores some of the more important configurations where the configuration energy is not very high. The study of condensed matter physics shows that the electrons in the crystal are disturbed by the periodic potential energy scattering, so that the electron vibration forms an energy gap. Therefore, the existence of the energy gap is firstly related to the composition of the solid, and is related to the structure of the crystal under a certain composition. This shows that whether the fitting form of the extracted symmetry energy coefficient considers the deformation dependence of the high-order term on the symmetry energy coefficient has a certain influence, but it is not significant.

4. Conclusions

For the first time, the WS4 model considers the surface dispersion effect on the correction of the nuclear mass near the drip line. The surface dispersion effect has a great influence not only on the symmetry energy but also on the shell correction. Compared with the experimental measurement kernel, the mass root mean square deviation is lower, which is the best result under the current average field frame. We found that the symmetry energy and its slope parameters play an important role in determining the density range of the inner shell, the phase structure of the pasta, and the phase transition properties of the shell core. In the framework of the push-to-shell model, the diagonalization of the Hamiltonian is pushed, and the single-particle energy level of the reflection asymmetry is obtained. At the same time, the nuclear deformation also affects the accuracy of the formula calculation. On this basis, the relevant formula is corrected appropriately. When studying symmetric energy based on nuclear structure and reaction, the deformation dependence of symmetric energy coefficient should be considered. Traditional droplet model considers that only surface energy and Coulomb term depend on nuclear deformation.

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