Theoretical investigation of the structure of ^{19}N*

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Abstract We have employed the shell model and Skyrme-Hartree-Fock methods to investigate the structure of the neutron-rich nucleus ^{19}N. The level scheme of ^{19}N from the shell-model calculation with the WBT interaction is displayed. The potential-energy-surface calculation with the SGII interaction implies that ^{19}N should be a deformed nucleus. The theoretical β-decay half life of ^{19}N reproduces well the available experimental data.

Key words exotic nuclei, nuclear structure, ^{19}N, shell model

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1 Introduction

In 1949, Mayer et al[1, 2] advanced that the very strong spin-orbit splitting in the single particle potential is an important cause of the existence of the experimental magic numbers. The independent particle model is the original nuclear shell model. The shell model theory greatly impulses the development of the theoretical research on nuclear structure, and it can explain the structures of most nuclei near the stability line very well.

With the advent of radioactive-beam facilities, more exotic nuclei have been produced and been studied, which promote the investigation on the structure of exotic nuclei. For instance, the possible existence of new neutron magic numbers for exotic nuclei has been discussed recently. The nuclei far from the valley of β stability usually undergo β decay. Some of them also undergo β-delayed particle emission. For exotic nuclei, β decay plays an important role in studying the nuclear structure. Furthermore, the nuclear deformation is also an important physical quantity. The Skyrme-Hartree-Fock method can be used to study the nuclear deformation. Investigation on the structure of single magic neutron-rich nuclei will be helpful to understand the possible new neutron magic numbers. Therefore, the investigation on the structures of neutron-rich oxygen isotopes becomes an interesting topic in recent years. As the mother nucleus of the β decay to oxygen, nitrogen also attracts our attention to study its structure.

For nitrogen isotope, the heaviest bound nucleus that has been observed so far is located at $A = 23$. In the β-decay research of nitrogen isotopes, ^{18}N has plenty of experiment data[3—6] and ^{20}N is the heaviest nucleus being observed experimentally by far[7]. So we will focus on the properties of the nucleus ^{19}N in this article. The first experiment on the nucleus ^{19}N is the β-delayed γ emission observed by Dufour et al[8] at GANIL in 1986. The β-decay halflife of ^{19}N was measured to be 0.32(10) s and three γ transitions were observed. The detailed calculations on the ^{19}N(β^-)^{19}O process were performed by Warburton[9] in 1988. The fp shell was included in the model space used in the calculation. Subsequently, Reeder[10] reported the β-decay halflife of the nucleus ^{19}N to be 0.271(8) s in 1995. In 2006, C.S. Sumithrarachchi et al[7] reported the β-delayed neutron emission and γ

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emission of ^{19}N.

In this article, the elementary structure and deformation of ^{19}N will be studied as the mother nucleus in the ^{19}N(β^-)^{19}O process. The shell model and Skyrme-Hartree-Fock methods will be employed. In the shell model calculation, the WBT interaction[11] is chosen. The possible deformation of ^{19}N will be studied with the SGII interaction. In addition, the β-decay halflife of the nucleus ^{19}N will also be discussed.

2 Calculations

The level scheme of the nucleus ^{19}N obtained from the shell model calculation is displayed in Fig. 1.

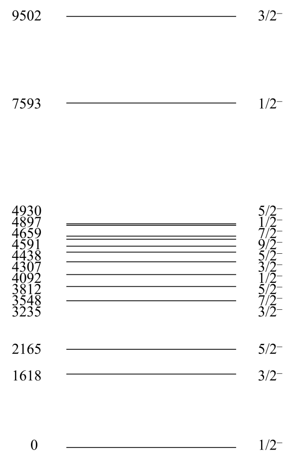

Fig. 1. The level scheme of ^{19}N obtained from shell model calculation.

The shell space chosen in this calculation is the *p*-*sd* shell space. The WBT interaction[11] is used as the effective Hamiltonian in this work. The theoretical ground state of the nucleus ^{19}N is $1/2^-$, which is consistent with the experimental data[12]. In Fig. 1, the structure of ^{19}N mainly comes from the contribution of *p* shell. The configuration of the ground state ($1/2^-$) is $1p^{11}(2s1d)^4$, which is a combination of 57% $1p^{11}(1d_{5/2})^4$, 23% $1p^{11}(1d_{5/2})^2(2s_{2/3})^2$ and 10% others. In addition, the shell model calculation is strongly supported by the good agreement between the theoretical β-decay halflife (0.339 s) of the nucleus ^{19}N and the experimental data (0.271 s)[10].

The Skyrme-Hartree-Fock method is also employed in this article to study the structure of the mother nucleus ^{19}N. Fig. 2 displays the potential-energy-surface of the nucleus ^{19}N obtained from the Skyrme-Hartree-Fock calculation with the SGII interaction, which shows that ^{19}N is likely to be a deformed nucleus with $\beta_2 = 0.21$.

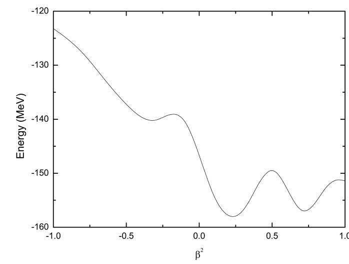

Fig. 2. The potential-energy-surface of the ground state of ^{19}N obtained from the Skyrme-Hartree-Fock calculation.

3 Summary

To understand the nuclear structure and the β-decay properties of the neutron-rich nucleus ^{19}N, calculations based on the shell model and Skyrme-Hartree-Fock methods have been performed in this work. The level scheme of the nucleus ^{19}N obtained from the shell model calculation is displayed, which shows that the structure of ^{19}N mainly comes from the valence particles in the *p* shell space. The potential-energy-surface calculation with the Skyrme-Hartree-Fock method with the SGII interaction implies that ^{19}N is likely to be a deformed nucleus with $\beta_2 = 0.21$. The β-decay halflife of the ground state of the nucleus ^{19}N obtained from the shell model calculation also agrees well with the available experimental data.

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