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Proton halo of Fl^{17} by skyrme hartree fock and core-polarization models

Ramendra Nath Majumdar

Nuclear Physics study centre, 30/41 Attapara lane, P. O. Sinthee, Kolkata-700050, India.

ramendranath48@gmail.com

Abstract

The proton halo of Fl^{17} has been investigated by skyrme hartree fock with Pauli blocking and core-polarization models. The skyrme hartree fock parameters have been optimized to obtain the shell-model proton energies of Fl^{17}, which are inducted in core-polarization model to get the energies and spectroscopic factors of the excited proton states. The theoretical results have been compared with the available experimental results. Finally, the proton density distribution has been obtained within skyrme hartree fock model.

Key words: Skyrme hartree fock method, proton density, core polarization effect, spectroscopic factors

Introduction

With the discovery of the radioactive ion beam, both the experimental and theoretical works of the neutron-proton rich drip line nuclei have received enormous importance [1-5]. With this end in view, an attempt has been taken to study the nucleus Fl^{17} by Skyrme Hartree Fock (shf) method and core-polarization model [6, 7]. The parameters of shf can be optimized by reproducing absolute binding energies of the magic nuclei. The shell model proton energies along with the occupation probabilities can ascertain the distinct proton halo of this nucleus. Finally, adopted shf parameters that reproduce the energies of the proton states can be utilized in the core polarization model to get the energy spectrum and the spectroscopic factors of the excited proton orbital of Fl^{17}. These theoretical findings can be compared with the available experimental results [8].

Materials and Methods

Core polarization model

The basic physics of the model has been described [6]. Here the total Hamiltonian of the physical system can be written as:

$$H=Hint + H\omega +Hp \qquad (1)$$

Here H is the total Mamiltonian, Hint is the interaction Hamiltonian, Hω is the vibrational Hamiltonian and Hp is the particle Hamiltonian. H is diagonalised in the basis $\{(N2\ R2, N3\ R3)\ R\ ;(\ nl1/2)\ j\}^{JM\Pi}>$ N2 and R2 are the quadrupole phonon numbers and the angular momenta. N3 and R3 are the same for octupole phonons. R is the coupled angular momentum of R2 and R3. Quantities within first bracket represent the shell-model proton states. J is the spin state with its projection M and parity ∏. The Hamiltonian matrix H of spin J is diagonalised to get eigen values and spectroscopic factors.

Skyrme Hartree Fock method

The salient features of the model have been discussed [8]. With shf parameters [8], Skyrme Hartree Fock Hamiltonian is set up as a basis of the eigen functions of an axially symmetric. The Hamiltonian is diagonalised with good quantum number Ω. The Pauli blocking effect is inducted through Uj and Vj, which are the non-occupational and occupational probabilities of the shell-model proton state respectively.

Results and discussion

shf parameters have been optimized to reproduce absolute binding energies of the magic nuclei O^{16}, Ca^{40} and Pb^{208} nuclei. With these parameters energies of 1s1/2, 1p3/2, 1p1/2, 1d5/2, 1d3/2, 2s1/2, 1f7/2 and 1f5/2 states have been calculated. The energies along with the corresponding occupation probabilities are depicted in table 1. Then the Hamiltonian matrices of these proton states are set up within the frame work of core-particle coupling model. The basis vectors have been constructed by coupling quadrupole 1 and 2 phonon states and octupole 1 phonon state of O^{16} with the above proton states. The Hamiltonian matrices are diagonalised to get energies and spectroscopic factors of the proton states of Fl^{17} and the results are depicted in table 2. From table 2, it is observed that the theoretical results coincide with the experimental ones and thereby showing the realistic values of the shf energies and weight factors of the shell-model states. From table 1, it is seen that last occupied shell-model state 1p1/2 and the first occupied shell-model state 1d5/2 possess the energy difference of 13.265 MeV and thereby reproduces an enormous gap showing the distinct proton halo of Fl^{17}. In addition, table 2 shows the coincidence of the theoretical and the available experimental findings, showing the signature of the fidelity of the adopted shf parameters.

Tab 1. The proton states in MeV with shell-model occupancy							
1s1/2	1p3/2	1p1/2	1d5/1	1d3/2	2s1/2	1f7/2	1f5/2
-28.06	-13.063	-13.058	0.207	0.213	-0.399	10.104	10.107

Table 2: Proton states in MeV with spectroscopic factors. The numerical figures within the bracket are experimental estimates[8]

state	energy	spectroscopic factor
5/2+	0.0(0.0)	0.81(1.3)
1/2+	0.65(0.50)	0.80(1.75)
1/2+	1.25	0.1
5/2+	3.45	0.008
5/2+	3.55	0.12
5/2+	4.56	0.007
7/2-	5.67	0.11
3/2+	6.06(5.67)	0.259(0.14)
3/2+	6.12(5.1)	0.68(0.54)
3/2+	6.45(6.62)	0.11(0.17)
3/2+	6.97(6.77)	0.12(0.06)
3/2+	7.23(7.36)	0.18(0.13)
3/2+	7.55(7.48)	0.11(0.04)
3/2+	8.5(9.41)	0.08(0.03)
7/2-	8.82(7.55)	0.12(0.13)
5/2+	9.13(8.43)	0.006(0.06)

References

1. Ramendra Nath Majumdar. (1999) *Phys. Rev.* C59, 3275.
2. Tanihata *et al.* (1985) *Phys. Rev. Letts* 55, 2676.
3. Lulu Li *et al*. (2012) *Phys. rev.* C85, 024312.
4. D J Moutford, A St J Murphy, N L Achouri, C Angulo, J R Brown, T Davinson, F de Oliveira Santos, N de Sereville, P Descouvemont, O Kamalou, A M Larid, S T Pittman, P Ujic and P J Woods (2012) Resonances in 19 Ne with relevance to the astrophysically important 18F(*p*,*α*)150 reaction, *Phys. Rev.* C(R)022801
5. I Hamamoto (2012), Neutron shell structure and deformation in neutron-drin-line nuclei, *Phys. Rev.* C85, 064329.
6. Ramen Majumdar, (1987) *J. Phys.* G13, 0429.
7. J Bartel *et al*. (1982) *Nucl. Phys.* A386, 79.
8. R Morlock et al (1997). *Phys. Rev. Letts*:793837, A A S Eldin et al: Table of isotopes, 7th edition, Lawrance Barkley Laboratory(U S A).