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Shell Model Calculations For Even-Even ^{42,44,46}Ca Nuclei

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Abstract
The energy levels and transition rates calculations of fp shell nuclei ^{42}Ca, ^{44}Ca and ^{46}Ca is studied in the framework shell model nuclear of configuration $1f_{7/2}$, $2p_{3/2}$, $1f_{5/2}$ and $2p_{1/2}$. By using FPD6, GXFP1 and BK3 effective interaction and Skyrme-Hartree Fock (Skx) and harmonic oscillator (HO) as residual interactions for calculate transition rates. A good agreement at comparison between our results and the experimental data.

1. Introduction

The isotopes of calcium lying between doubly magic ^{40}Ca and ^{48}Ca provide a unique laboratory for examining the foundation of *fp* shell model calculations. Available spectroscopic information on odd mass Ca isotopes, mean charge radii, excitation energies, $B(E2 : 0_1^+ \longrightarrow 2_1^+)$ values and electric quadruple moments of the 2_{1+} states in even mass Ca nuclei have all indicated that 40Ca was not a good closed shell nucleus. Already in 1967 it had been postulated that a breakdown of the $Z = 20$ shell closure, caused by the promotion of *sd* shell protons into the *fp* shell, was responsible for the observed spectroscopic properties [1].

The Ca isotopes have been the subjects of much experimental and theoretical interest. This is in large part due to the fact that ^{40}Ca and ^{48}Ca, which occupy the ends of the stable isotope series for this element, are both doubly magic nuclei within shell model theory. For this reason, knowledge concerning the structure of the ground- and excited-state charge distributions of these two isotopes is of particular value in elucidating the general systematic of nuclei in this region[2].

Nuclei with valence nucleons in the *fp* shell have been intensively studied and discussed in recent years following the striking progress in the development and refinement of large-scale shell model calculations [3].

In the present work, the level schemes and transition probabilities are studied for ^{42}Ca,^{44}Ca and ^{46}Ca . the core is taken ^{40}Ca for nuclei in the *fp* shell, by generating the wave functions of a given level schemes and transition probabilities in known nuclei by adopting code Oxbash [4] and FPD6, GXFP1 and KB3 interactions.

2.Shell Model Calculations

The importance of including the whole *fp* shell in the description of the structure of these nuclei at an increasing number of valence nucleons [3]. The rates transition calculations was performed using Skx [5] and HO[6] as effective residual interactions with FPD6[7] for ^{42,44,46}Ca and using code Oxbash[4].

The core ^{40}Ca is taken for this nuclei and model space *fp* with effective interactions FPD6 [7], GXFP1 [8] and KB3 [9] to calculate the energy levels.

3.Results and discussion

In Fig.1. we present the theoretical level schemes for ^{42}Ca employing FPD6, GXFP1 and KB3 are compared with the experimental data. The prediction of Ex(2_1^+) in the interaction gx1fp is better than FPD6and KB3,while the FPD6 in high spin states is given a good agreement with experimental data.

The predicted spectrum of ^{44}Ca presented in Fig.2. shows, the first excitation (2_1^+) state in KB3 is very close for experimental data than fpd6 and gx1and still fpd6 is in better agreement in describing the high spin states, the fpd6 predicts level sequens J= $4_2,6_1,5_1,8_1$ are in acceptable agrees,while GXFP1 and KB3 predicts *J*= $4_2,6_18_1,5_1$.

The experimental energy levels for ^{46}Ca are comparing with theoretical work as in Fig.3. We found that the calculated results in acceptable agreement with experiment data, but shell model calculations with effective interaction GXFP1 in this nucleus are in good agreement with the experimental data from FPD6 and KB3.

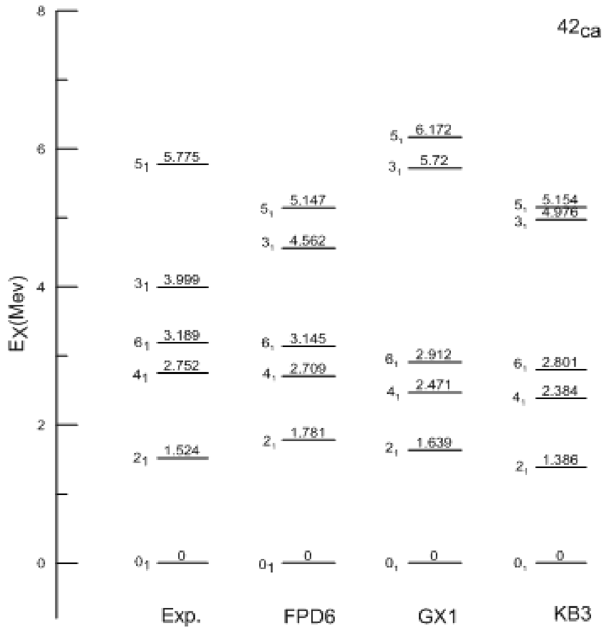

Fig.(1) The Comperssion between Theortical value and Experimental data [10]

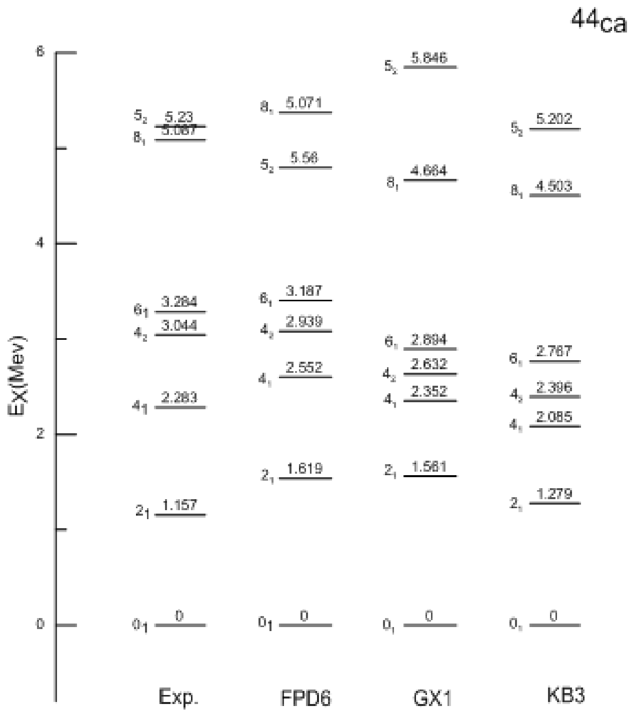

Fig.(2) The Comperssion between Theortical value and Experimental data [11]

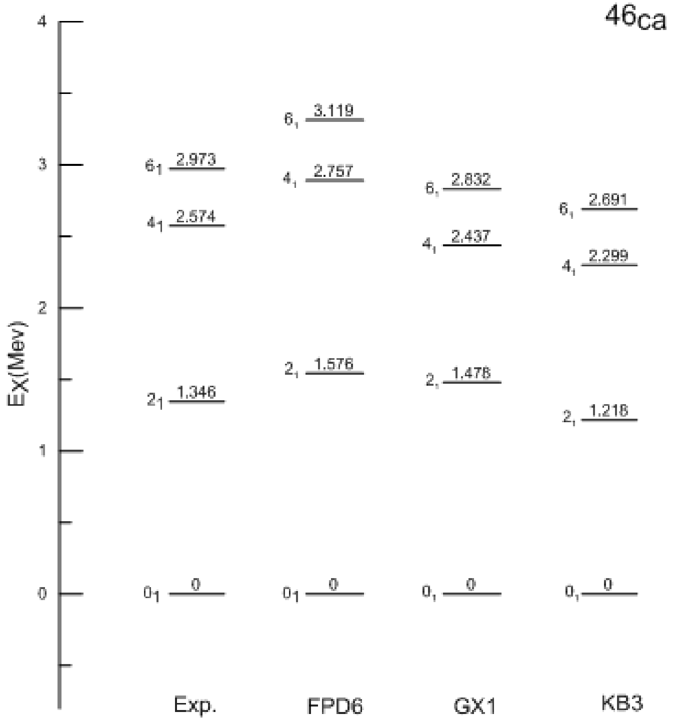

Fig.(3) The Comperssion between Theortical value and Experimental data [12]

In table .1. The electromagnetic transition probability B(E2; $0_1^+ \longrightarrow 2_1^+$) values calculated for *fp* model space and FPD6 with Skyrme- Hartree- Fock and harmonic-oscillator potentials as residual interactions. From the table we can see that our calculations in Skx is in excellent agreement with experimental data for ^{42}Ca , and BE2 for ^{44}Ca is agreement with experimental data in ho that is better than sk20. The calculated B(E2) value is found in ^{46}Ca with the use of Skx and HO is far from the measured value as appear in table, This is due to the use of different effective charge.

TABLE1: Theoretical values of the reduced transition probabilities B(E2) in units of $e^2\ fm^4$ and in comparison with experimental values.

Nucleus	$J_f^{\pi}\ T_f$	Exp.[13]	Sk20	HO.	
^{42}Ca	2_1^+ 1	420(30)	421.3	499.7	
^{44}Ca	2_1^+ 2	470(20)	4285		5027
^{46}Ca	2_1^+ 3	182(13)	385.9	450.2	

4- Conclusions

Shell model calculations were performed using the model space *fp* by taking ^{40}Ca as core for ^{42}Ca,^{44}Ca and ^{46}Ca. The results of shell model calculations in agreement with experimental data.

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