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STUDY OF THE SPECTRUM OF COLLECTIVE EXCITATIONS OF ^{6}He AND ^{6}Li IN THE MINIMAL APPROXIMATION OF THE METHOD OF GENERALIZED HYPERSPHERICAL FUNCTIONS

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The spectrum of the levels having positive and negative parities in the ^{6}He and ^{6}Li nuclei has been calculated in the basis of the translationally-invariant oscillator functions of the minimal approximation of the method of generalized hyperspherical functions. The dependence of the energy of these levels on the values of the oscillator radius and on the dimensionality of the basis of the functions resorted to has been investigated.

In [1-3], it was demonstrated that the basis functions of the irreducible representation of the group Sp(2,R) dominate among the basis functions of the irreducible representation of the group Sp(6,R) which are constructed on the internal state of the minimal approximation of the method of generalized hyperspherical functions. The latter belongs to a definite irreducible representation of the group O(A - 1), while the indices $[f_1 f_2 f_3]$ of its O(A - 1)-symmetry are associated with the indices $[p_1 p_2 p_3]$ of the irreducible representation of Sp(6,R) by the relationships

$$p_1=\frac{1}{2}f_1+\frac{A-1}{4},\quad p_2=\frac{1}{2}f_2+\frac{A-1}{4},\quad p_3=\frac{1}{2}f_3+\frac{A-1}{4}.$$

The basis Sp(2,R) is a portion of the basis Sp(6,R) and contains only those basis functions whose indices $(\lambda\mu)$ of SU(3)-symmetry satisfy the conditions

$$\lambda=f_1-f_2+2k,\quad \mu=f_2-f_3,$$

where k = 0,1,2,..., 2k being equal to the total number of oscillatory excitation quanta of the basis function relative to the state having the minimum allowable number of quanta. In the present work the oscillatory basis of the irreducible representation of Sp(2,R) is used to study collective excitations of ^{6}He and ^{6}Li nuclei. Calculation of the spectrum of collective excitations of positive parity over the internal state having O(5)-symmetry [20], and of the collective excitations of negative parity over the internal state [30]. The Volkov [4] and Brink-Boeker [5] potentials were taken as the potentials for the interaction between nucleons. The matrix elements of the Hamiltonian on the basis functions of the irreducible representation $I=\frac{1}{2}f+\frac{1}{4}$ of the group Sp(2,R) (f = 2 for O(5)-symmetry [20]; f = 3 for O(5)-symmetry [30]) were calculated by means of generating matrix elements.

Figure 1 shows the dependence of the approximate value of the energy of the ground state 0^+ of the considered nuclei and of the lowest 2^+-state on the choice of the oscillator radius r_0 (r_0 is the sole parameter of the oscillator-basis functions). The number above each curve corresponds to the number of involved basis functions. A similar dependence on r_0 is also characteristic for the negative-parity levels. All of the curves have a deep minimum, and therefore optimization of the approximate value of energy with respect to r_0 is required in order to accelerate the convergence of the iteration procedure and must be performed for all of the lowest states among those which have a specified orbital momentum and a specified parity.

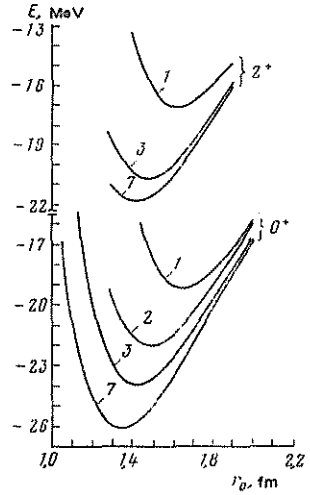

Fig. 1

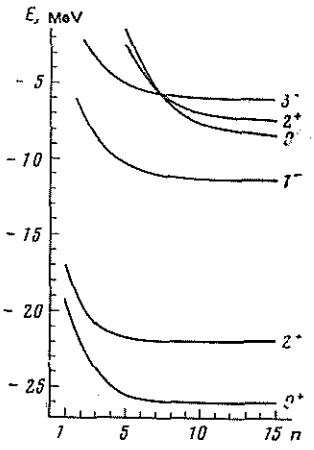

Fig. 2

Fig. 1. Dependence of the energy of the ground 0^+- and first excited 2^+-states on the values of the oscillator radius r_0 (the Volkov potential [4]). The numbers next to the curves represent the basis dimensionality with which this energy was obtained.

Fig. 2. Convergence of the energy of different I^π-states when the basis n of the oscillator functions is increased (Volkov potential [4]).

Energies of the Excited States, MeV

Potential	$I^\pi=0+$	2_1+	1_1-	0_1+	2_2+	3_1-
Brink-Boeker	−25,27	4,26	13,96	17,03	18,34	19,29
Volkov	−26,11	4,08	14,66	17,62	18,64	20,07

Figure 2 shows how the approximate energy value for various states varies with an increase in the number n of involved basis functions for optimal values of the oscillator radius r_0. The curves given in Fig. 2 demonstrate the rapid convergence of the iteration process. Thus, for the lowest states having a specified value of orbital momentum, no more than seven basis functions are sufficient for arrival at the limiting energy value. For other states the number of involved basis functions should be increased somewhat.

The results of the calculations of the energy spectrum of the collective excitations are displayed in the table. The energy of the excited states is reckoned from the energy of the ground state 0^+. All of the excited states may be treated merely as resonances whose width is determined by the interaction between the collective degrees of freedom and the degrees of freedom associated with the open channel α-d and the other channels which open at higher energies. In order to calculate the width of these resonances, it is necessary to broaden the basis of Sp(2,R) by involving the oscillator functions relative to the motion of the clusters of the open channels. Of course, under these conditions the energy of the resonances which is obtained without consideration of the open channels may change somewhat.

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