AN ANALYTICAL METHOD FOR THE INVESTIGATION OF TRIAXIAL SHAPES IN NUCLEI

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ABSTRACT

It is shown how the overlap integrals which appear in the application of the projected Hartree-Fock and Hartree-Fock-Bogoliubov theory can be analytically evaluated. The applicability of the proposed formalism is discussed.

Several recent investigations[1,2] involve the existence of triaxially deformed nuclei. In the approaches used so far one is usually faced with the problem of computing scalar products of the form

$$\sum_{K,K'} \langle \Phi | H P^I_{KK'} | \Phi \rangle \quad \text{(H=Hamiltonian)} \tag{1}$$

with

$$P^I_{KK'} = \int R(\Omega)\, D^I_{K'K}(\Omega)\, d\Omega \tag{2}$$

$R(\Omega)$ being the rotation operator, $D^I_{K'K}(\Omega)$ the rotation matrix and Ω the Euler angles. $|\Phi\rangle$ is the N-particle state which can be a Slater determinant or a BCS wave function. On writing

$$\sum_{KK'} = \overline{\sum_{\substack{K+K'<0\\ K\geq K'}}} + \sum_{\substack{K+K'<0\\ K'>K}} + \overline{\sum_{\substack{K+K'\geq 0\\ K\geq K'}}} + \sum_{\substack{K+K'\geq 0\\ K'>K}} \tag{3}$$

and using standard formulae for the appearing rotation matrices as well as the relation[3]

$$\int_{-1}^{+1} (1+t)^h (1-t)^k P_n^{(a,b)}(t)\, dt = 2^{h+k+1} B(h+1,k+1)\,\cdot$$
$$ {}_3F_2(-n, a+b+n+1, k+1; a+1, h+k+2; 1) \quad , \tag{4}$$

where B(h+1,k+1) and ${}_3F_2(-n,a+b+n+1,k+1;a+1,h+k+2;1)$ denote the Beta Function and the generalized hypergeometric function, respectively, and $P_n^{(a,b)}(t)$ is the Jacobi polynomial, we can give simple exact expressions for the overlaps in question. The mathematical details of the method for the case of Slater determinants are found in ref.[4].

Here we want to stress that due to the theorem of Thouless[5] the treatment of eq.(1) when $|\varphi\rangle$ is of the BCS type is very similar since a BCS wavefunction can be regarded as a generalized Slater determinant. This fact leads us to conjecture that the present approach may be suitable in searching for triaxial shapes of nuclei because detailed microscopic investigations usually utilize the HFB method[6] combined with the projection technique. In the course of such calculations the computational burden may be diminished if the aforementioned overlaps do not need to be numerically calculated. In this way one might save computer time.

It is noted that the proposed method may be applied to heavy nuclei since no special assumptions are made in working out the rigorous expressions.

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