A TWO PARAMETRIC GENERATOR COORDINATE WAVE FUNCTIONS FOR LIGHT NUCLEI

N.Mankoč-Borštnik and M.V.Mihailović
J.Stefan Institute,Faculty of Natural Sciences and Technology and University of Ljubljana, Ljubljana, Yugoslavia

In calculating low lying states of light nuclei the following N body trial function is proposed:

$$\psi^J(r) = \Sigma \int d\eta \ \ d\varepsilon \ f_k^J(\eta,\varepsilon) \ \phi_k^J(r,\eta,\varepsilon).$$

The generator function $\phi_k^J(r,\eta,\varepsilon)$ is obtained by projecting the component with good angular momentum from a Slater determinant of generalized Nilsson's single particle functions. The two parameters $\eta = \beta/C$ and $\varepsilon = D/C$ are defined through the Nilsson's potential

$$h_{Nilsson} = h_{spherical} + \beta r^2 Y_{2o} + C \, l \, s + D l^2.$$

The parameter η is Nilsson's deformation parameter, the parameter ε is related to the relative position of 1d to 2s single particle states. The index k goes over a few values and means different single particle configurations.

The results of investigations of the basis spanned by the proposed trial function for ^{20}Ne are presented. Only one choise of configuration $\phi_0^J(r,\eta,\varepsilon)$ is taken, related to the lowest energy. The projection of angular momentum was performed by a method[1] using $e^{-\pi J+} \ e^{J-}$ as the projecting operator. As an effective nuclear interaction we took Rosenfeld mixture with Yukawa radial dependent potential. We took single particle energies from experimental data: $\varepsilon d \ 5/2 = 4.8$ MeV, $\varepsilon d \ 3/2 = 9{,}9$ MeV,

The Hill-Wheeler equations were solved numerically[2] by choosing a few values for η and ε.

The purpose of this preliminary calculation is to explore the importance of GC parameters η and ε. The calculations shows that both parameters η and ε together cause an appreciable lowering of the ground state energy compaired to the energy obtained by varing Nilsson's deformation parameter only.

Table 1

Zuker's model of ^{16}O (ref.4) = inert ^{12}C core +4 valence nucleons in $1p_{1/2}$, $1d_{5/2}$ and $2s_{1/2}$ subshells interacting by a modified Kuo interaction

HOM = particle-hole level in the Hermitian Operator Method

ERPA = particle-hole level in the extended RPA

Exact level = Zuker's result with full diagonalization

$|\psi_g\rangle$ (in HOM and ERPA) = approximate ground state (Variational Approach to Density Matrices

JPT	HOM	Exact level	Exper.	ERPA
0+0	3.83	5.83	6.05	-
0+1	14.07			-
0-0	8.70	9.39	10.95	15.34
0-1	11.62	12.10	12.79	17.81
1+0	81.33			-
1+1	16.44			-
1-0	8.08	7.34	7.12	12.47
1-1	13.05	12.82	13.10	19.98
2+0	6.71	6.93	6.92	685
2+1	14.38			1241
2-0	9.30	8.52	8.88	12.73
2-1	13.85	12.46	12.97	16.21
3+0	12.73			1014
3+1	15.23			1299
3-0	6.80	6.22	6.13	10.04
3-1	14.30	12.82	13.26	17.20
4+0	10.63	10.33	10.36	-
4+1	15.23			-
5+0	165.	15.5	16.	
5+1	17.69			-

Table 2

Whitehead's model[5)] of ^{28}Si and ^{20}Ne = inert ^{16}O core+12 (or 4) valence nucleons in $1d_{5/2}$, $2s_{1/2}$ and $1d_{3/2}$ subshells interacting by bare Kuo interaction

HOM = particle-hole level in the Hermitian Operator Method

Exact level = Whitehead's result with full diagonalization

$|\psi_g\rangle$ (in HOM) = exact ground state (full diagonalization within the given subspace)

IPT	Si HOM	Si Exact level	Si exper.	Ne HOM	Ne Exp.
0+0	10.85	3.86	4.98	7.29	6.72
0+1	13.14			13.18	
1+0	12.95	8.5	8.33	12.80	10.31
1+1	14.10			12.12	
2+0	1.48	1.18	1.78	1.63	1.63
2+1	14.11			10.95	9.50
3+0	10.81	7.07	6.28	11.52	
3+1	14.11			11.71	
4+0	7.95	4.2	4.62	4.81	4.25
4+1	14.80			12.09	
5+0	15.54			13.42	
5+1	15.42			13.26	

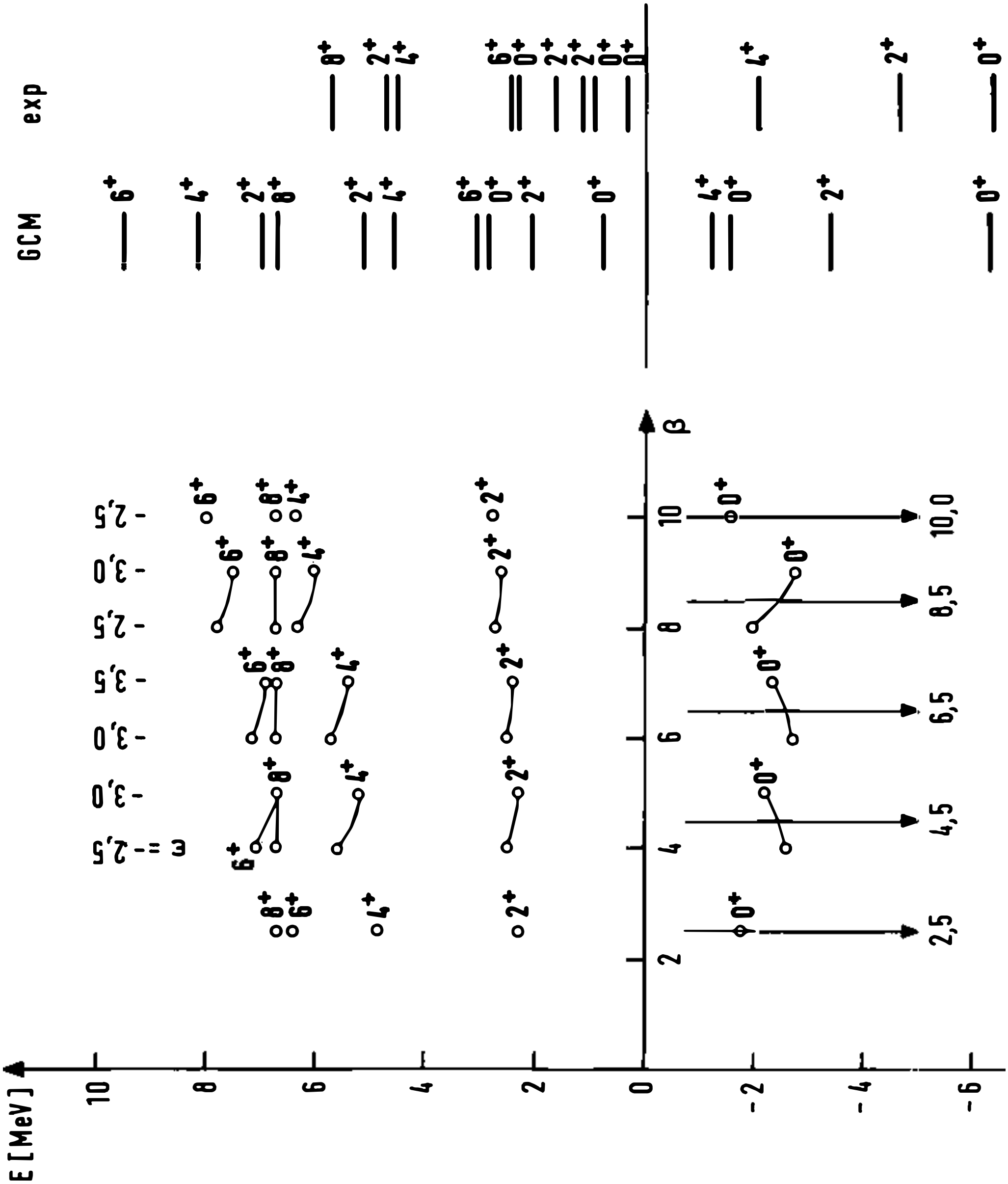

Fig. 1.Low lying spectra of ^{20}Ne. On the left hand side are the energy spectra obtained by projecting angular momenta from a single Slater determinant for a fixed pair of values of parameters η and ε. On the right hand side are results of GCM calculation with these Slater determinants as generator functions. For comparison, the experimental spectrum is drown also.

Spectra of ^{20}Ne from different generator coordinate calculations are presented.

References:

1) N.Mankoč, M.V. Mihailović: A method for the projection of angular momentum - to be published

2) Generator Coordinate method for nuclear bound states and reactions. A review edited by M.V. Mihailović, M. Rosina, Fizika, Volume 5, 73, Supplement.

DESCRIPTION OF COLLECTIVE STATES IN THE PARTICLE-HOLE SPACE

M. Rosina, Faculty of Natural Sciences and Technology, and Institute "J.Stefan", University of Ljubljana,Ljubljana,Yugoslavia

We use as the definition of the particle-hole space the space spanned by the basis $|ab\rangle = (a_a^+ a_b - \rho_{ab})|\psi_g\rangle$, where $\rho_{ab} = \langle\psi_g|a_a^+ a_b|\psi_g\rangle$ is the one-body density matrix. For the "approximate ground state" $|\psi_g\rangle$ we use a correlated state which represents closely the ground state $|g\rangle$ and which is available from other calculations.

There are some qualitative arguments for the relevance of the particle-hole space.

(i) There are several examples in the modern formalisms like Projected Hartree-Fock, N-projected BCS, Generator Coordinate Method, where some low-lying excited states lie entirely in the particle-hole space of the ground state.

(ii) Low-lying states are likely to have many correlations similar to the ground state. So it is usually convenient energywise not to break correlations when constructing low-lying excited states.The particle-hole states are constructed by acting with a one-body operator on the correlated ground state; therefore one may except that many correlations characteristic for both the ground state and low-lying excited states are preserved.