MODELS WITH FEW DEGREES OF FREEDOM APPLIED TO SPECTRA OF LIGHT NUCLEI

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In the study of nuclear structure one tries to find a small number of important degrees of freedom which are responsible for the features of low-lying spectra. One rather successful but expensive model for light nuclei is the complete diagonalization in a small model space[1] where the effects of the rest of the space are approximately included in the effective interaction. The degrees of freedom refer to a small number of valence nucleons (typically 2-12) moving in a small single-particle space (typically 3 subshells). These valence nucleon are supposed to be responsible for the main features of several low--lying levels.

Our aim is to describe several levels with much fewer degrees of freedom. In the generator coordinate method (GCM)[2,3] we take for lower 1d2s nuclei two degrees of freedom - the quadrupole deformation β and the parameter μ. They are defined by means of the Nilsson-like single-particle field

$$\hat{h}(\beta,\mu) = \hbar\omega_o \frac{1}{2}(-\nabla^2 + r\ ) + \hbar\omega_o\beta r^2 Y_{20} + C\,ls + \mu C l^2$$

which generates the single-particle states occupied in our Slater determinants $\phi(\beta,\mu)$. One then diagonalizes the Hamiltonian in the space of the wave functions

$$\Psi^J = \int f^J(\beta,\mu) P^J\ \phi(\beta,\mu)\ d\beta d\mu$$

Here P^J is the projector on the subspace of good angular momentum J. The collective degrees of freedom "β-vibrations" and "μ-vibrations" are used to generate an appropriate N-body space of rather small dimension.

In the hermitian operator method (HOM)[4,5] we introduce as degreed of freedom all possible "particle-hole" excitations" with the respect to the ground state $|g>$:

$$\sum_{ab} Q_{ab}(a_a^+ a_b + a_b^+ a_a)|g> .$$

The Schrödinger equation in this subspace has the form

$$\sum_{cd}\left\{ <g|\,|a_a^+a_b + a_b^+a_a, |H, a_c^+a_d + a_d^+a_c|\,|\,|g>\right\}Q_{cd} =$$

$$= \omega \sum_{cd} \left\{<g|\,(a_a^+a_b + a_b^+a_a)\,(a_c^+a_d + a_d^+a_c)\,|g>\right\}Q_{cd}$$

Here ω is the excitation energy and g should be a good approximation to the exact ground state in the given model space. The two-body density matrix of the ground state is needed as input information.

The generator coordinate method can be formally represented as describing a system of anharmonic, interacting phonons. In our case we have states with several phonons of two kinds ("β-phonons" and "μ-phonons"). On the other hand, the particle-hole states in the hermitian operator method can be formally represented as one-phonon states of several kinds of phonons (each level is a different phonon). Such representation may offer a bridge between our description of light nuclei and the description of heavier nuclei by the Alaga group[6].

In Fig. 1. some low-lying levels of ^{20}Ne are calculated with GCM[2] (even J, $T=0$) and HOM[4] (the lowest level for each J and T) and they are compared with the result of complete diagonalization[1]. For each J and T subspace of small dimension is taken (1-6 for GCM, 1-5 for HOM) compared to the complete diagonalization (3-56). We are preparing calculations of odd and even parity states in a larger single-particle space (3 major shells), using both GCM and HOM.

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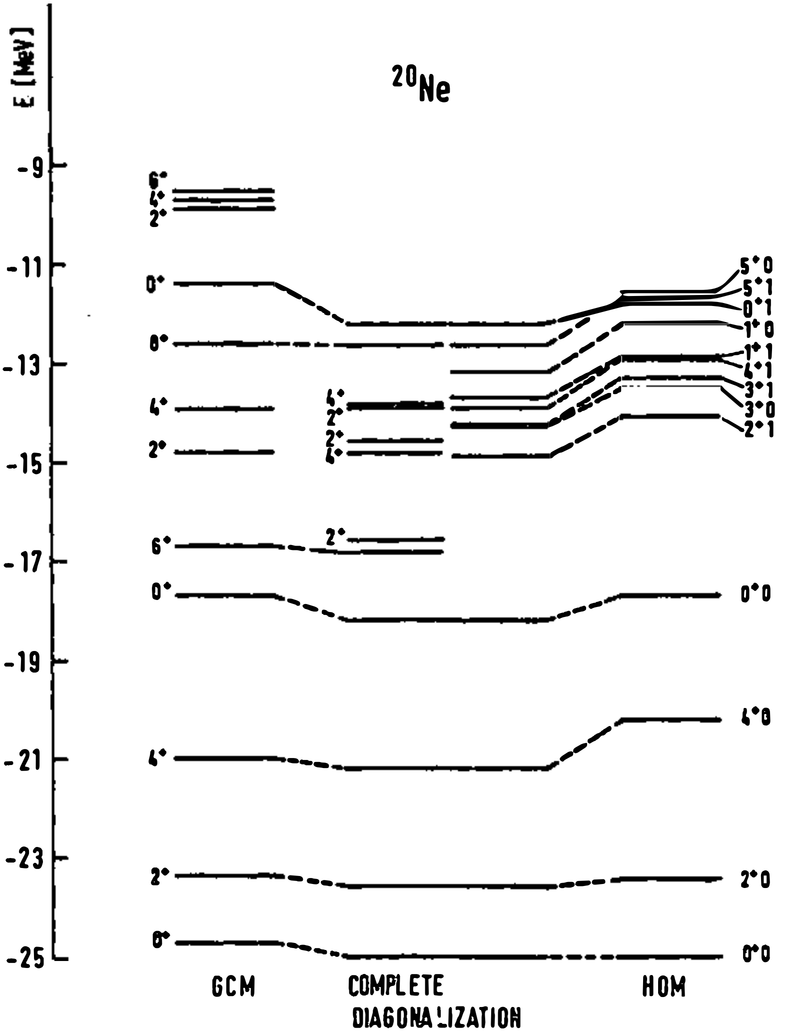

Fig. 1.