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# A self-consistent multiphonon approach to spectroscopic properties of even and odd nuclei

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## Summary

Several extensions of the random-phase approximation (RPA) have been adopted to study the fragmentation of the giant dipole resonance (GDR) and, in general, the anharmonic features of the nuclear spectra. Relativistic quasiparticle time blocking approximation (RTBA) [1], second RPA (SRPA) [2, 3], and the quasiparticle phonon model (QPM)[4] are some of them.
We have proposed an equation of motion phonon method (EMPM) [5, 6] which de- rives and solves iteratively a set of equations of motion to generate an orthonormal basis of multiphonon states built of phonons obtained in particle-hole (p − h) Tamm-Dancoff approximation (TDA). Such a basis simplifies the structure of the Hamiltonian matrix and makes feasible its diagonalization in large configuration and phonon spaces. The di- agonalization produces at once the totality of eigenstates allowed by the dimensions of the multiphonon space. The formalism treats one-phonon as well as multiphonon states on the same footing, takes into account the Pauli principle, and holds for any Hamiltonian.
The method was adopted mainly to investigate the dipole response in the heavy, neu- tron rich, 208Pb [8, 9] and 132Sn [10]. Fully selfconsistent calculations using a Hamiltonian composed of an intrinsic kinetic term and an optimized chiral potential NNLOopt [7] have emphasized the crucial role of the two-phonon basis in enhancing greatly the fragmentation of the GDR and the density of low-lying levels associated to the pygmy dipole resonance (PDR), consistently with experiments.
Recently, the method has been formulated in terms of quasiparticles and applied to the open shell neutron rich 20O. A calculation using a Hartree-Fock-Bogoliubov basis derived from the same chiral Hamiltonian has shown that the low-lying spectrum can be repro- duced only once the two-phonon basis is included. The two phonons have an important quenching effect on the dipole response, necessary for reproducing semi-quantitatively the experimental cross section in both GDR and PDR regions.
The method has been extended, now, to odd nuclei with one particle external to a doubly magic core. An analogous set of equations is derived and solved iteratively to generate an orthonormal basis of states composed of a valence particle coupled to n phonons (n = 1,2,…n…) generated within the EMPM.
A self-consistent calculation, using the same chiral potential in a space including up to two phonons and, under some simplifying assumptions, three phonons, has been performed for the A=17 nuclei. The multiphonon states enhance enormously the density of levels and compress the whole spectrum, consistently with the data. They contribute substan- tially to improve the agreement with the experimental moments and transitions strengths. Moreover, they exert a crucial quenching action on the dipole response, necessary for reproducing the cross section in GDR and PDR regions.

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