An *ab-initio* multiphonon approach to low- and high-energy spectroscopy of odd nuclei

G. De Gregorio[1,2], F. Knapp[3], N. Lo Iudice[2,4], P. Vesely[1]

[1] *Dipartimento di Matematica e Fisica, Università degli Studi della Campania "Luigi Vanvitelli", viale A. Lincoln 5, I-8110 Caserta, Italy*

[2] *Istituto Nazionale di Fisica Nucleare (INFN), sezione di Napoli, Napoli, Italy*

[3] *Institute of Particle and Nuclear Physics, Charles University, Prague, Czech Republic*

[4] *Dipartimento di Fisica, Università di Napoli Federico II, Napoli, Italy*

Different methods have been developed to study the modifications of the single-particle states in odd nuclei induced by the core excitations, our proposal is the Equation of Motion Phonon Method (EMPM). This method, widely adopted for studying spectra and giant resonances of even-even nuclei, has been extended to odd nuclei. It derives and solves iteratively a set of equations of motion to generate an orthonormal basis of multiphonon states. Such a basis simplifies the structure of the Hamiltonian matrix and makes feasible its diagonalization in large configuration spaces. The diagonalization produces at once the totality of eigenstates allowed by the dimensions of the multiphonon space.
The formalism does not rely on any approximation, takes into account the Pauli principle, and holds for any Hamiltonian.
Self-consistent calculations of odd nuclei around A=16 and A=22 using an optimized chiral potential NNLO_{opt}[1] have emphasized the role of the multiphonon states for describing spectra and giant resonances [2, 3, 4, 5].
The multiphonon states enhance enormously the density of levels consistently with the data. They contribute substantially 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.
However some discrepancies remain. These discrepancies were ultimately traced back to the large separation between the Hartree-Fock levels belonging to different major shells. It was suggested that a more compact single particle spectrum is needed and can be generated by a new chiral potential which includes explicitly the contribution of the three-body forces.

1. A. Ekström *et al.* Phys. Rev. Lett.**110** 192502 (2013).
2. G. De Gregorio *et al.* Phys. Rev. C **94**, 061301(R) (2016) .
3. G. De Gregorio *et al.* Phys. Rev. C **95**, 034327 (2017).
4. G. De Gregorio *et al.* Phys. Rev. C **97**, 034311 (2018).
5. G. De Gregorio *et al.* Accepted for publication in Phys. Rev. C (2019).