



NUSTAR monthly Seminar

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Shell model: recent advances from mid-mass to superheavy elements

In this presentation, I will expose some of the latest developments in microscopic nuclear structure calculations from mid-mass to superheavy elements. In a first part, I will present developments and applications for the diagonalisation of shell-model hamiltonians in a Discrete Non-Orthogonal Shell Model (DNO-SM)[1] and its latest implementation DNO-SM(VAP)[2]. The method is based on mean-field and beyond-mean field techniques with focus on basis states optimization within a double variation after projection approach. Numerical applications are benchmarked and illustrated against Large Scale Shell Model diagonalisations.

In a second part, this new development will be used to address the subject of high collectivity along the $N=Z$ line. In particular, heavy $N=Z$ nuclei in the mass region $A=80$ are expected to be some of the most deformed ground states which have been found[3] in mid-mass nuclei, typically $8p-8h, 12p-12h$ for e.g. the cases of ^{76}Sr , ^{80}Zr and more recently extended to ^{84}Mo and ^{86}Mo . This strong enhancement of collectivity with respect to lighter $N=Z$ nuclei has its origin in cross shell excitations across the $N=40$ shell gap to $g_{9/2}$, $d_{5/2}$ and $s_{1/2}$ which are intruder quadrupole partners generating deformations. I will interpret these structures in terms of the simple Nilsson-SU3 algebraic model[4]. New theoretical calculations for the very region of ^{80}Zr will be presented within the interacting shell model framework from both exact Shell Model diagonalisations and DNO-SM(VAP) approaches[5]. This whole region of collectivity is identified as a new Island of Inversion at the $N=Z$ line.

The DNO-SM(VAP) approach also allows to study superheavy systems within the Shell Model framework and I will present and discuss the first complete description of low-lying spectroscopy in ^{254}No [2] as well as dipole excitations in ^{242}Pu . Finally I will discuss the new perspectives opened with these recent advances.

[1] D. D. Dao and F. Nowacki, Phys. Rev. C 105, 054314 (2022),

[2] D. D. Dao and F. Nowacki, arXiv:2409.08210

[3] R. D. O. Llewellyn et al., Phys. Rev. Lett. 124, 152501 (2020).

[4] A. P. Zuker et al., Phys. Rev. C 92, 024320 (2015)

[5] D. D. Dao, F. Nowacki, A. Poves in preparation

Convener: M. Gorska-Ott

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