NCSM spectroscopy calculations for Ca$^{48}$, Sc$^{48}$, Ti$^{48}$

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Physics motivations:

- $0\nu$ - DBD (Double Beta Decay) process is currently under intense investigation theoretically and experimentally (16 experiments running or to run in the near future).
- Its impact on physics is potentially very high especially if the neutrinoless process is discovered.
- $0\nu$ – DBD can complete the information coming from neutrino flavour oscillations --> Dirac or Majorana nature.
- A precise treatment of nuclear many body system is still needed and the NCSM offers a new opportunity for Ca$^{48}$, Sc$^{48}$ and Ti$^{48}$.
- Our first goal was to achieve a good spectroscopy of these three nuclei.
Theoretical backgrounds:

- Ab initio No Core Shell Model (NCSM) calculation method

- We explore a limited range of $\hbar\Omega$ around $40/A^{1/3}=11$ MeV

- Model space is limited to $1\hbar\Omega$, for now

- Neutron-proton basis→full isospin mixing allowed

- No spurious center of mass motion effects
Phenomenological adjustments:
• To obtain the NCSM fit to the A=48 region we investigated the minimal modifications to the theoretical Hamiltonian for improving the spectroscopic properties:
  • The total binding energies
  • Low lying excited state

Best description is the following:
\[ V(r) = V_0 \exp\left(-\frac{(r/R)^2}{r^2}\right) + V_1 \exp\left(-\frac{(r/R)^2}{r^2}\right) + V_t S_{12}/r^3 \]

Central strengths
\[ V_0 = -14.4 \text{ MeV-fm}^2 \]
\[ V_1 = -22.61 \text{ MeV-fm}^2 \]
\[ R = 1.5 \text{ fm} \]

Tensor strength
\[ V_t = -52.22 \text{ MeV} \]
\[ S_{12} - \text{conventional tensor operator} \]
M-scheme dimensionality:
-2921360 in $1\hbar\Omega$ and
-12022 in $0\hbar\Omega$,
M-scheme dimensionality:
-139046 in $0 \hbar \Omega$, 

$^{48}$Sc

$\hbar \Omega = 10$ MeV
M-scheme dimensionality:
-634744 in 0\(\hbar\Omega\)
Conclusion and outlook

- We have made a proof of principle with these calculations.
- For future we would like to extend to bigger model spaces.
- Currently we are investigating the electromagnetic and weak transition properties.
Thank you!