Mean Field and Beyond Mean Field Calculations of Hypernuclei for Study of Electroproduction

Author: **Petr Veselý,** *Nuclear Physics Institute, Czech Academy of Sciences, Řež, Czech Republic*
List of Collaborators: **P. Bydžovský, G. De Gregorio, D. Denisova, F. Knapp, N. Lo Iudice, D. Petrellis, J. Pokorný, D. Skoupil.**

Abstract:

We present two methods, the Nucleon-Lambda Tamm Dancoff Approximation (NΛ TDA) and the Equation of Motion Phonon Method (EMPM) suitable for calculating hypernuclear energy spectra and structure. These methods are applicable for hypernuclei of wide range of masses with one Lambda particle replacing one nucleon in an even-even nuclear cores. Using an effective Lambda-nucleon potential both methods were applied to calculate the energy spectrum of $^{12}_{\Lambda}$B and also one body density matrix elements (OBDME). The OBDME were applied to calculate the cross section in electroproduction of $^{12}_{\Lambda}$B. We obtained reasonable agreement with the previous theoretical studies and the experimental data. This allows us to provide theoretical prediction (by applying the same methods and Lambda-nucleon potentials) of the cross section in electroproduction of $^{40}_{\Lambda}$K and $^{48}_{\Lambda}$K.

Theoretical Formalism:

NΛ TDA is an extension of Tamm Dancoff Approximation which describes hypernuclear states as linear superposition of 1 Λ creation – 1 nucleon annihilation configurations. NΛ TDA phonon operator:

$$R^{\dagger}_{\nu}|HF> = \sum_{ph} r^{\nu}_{ph} c^{\dagger}_{p} a_{h} |HF>$$

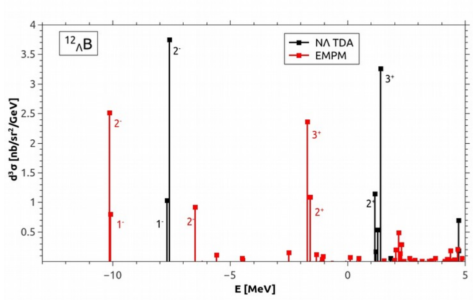
For details see **Phys. Scr. 94, 014006, (2019).**

EMPM is a method used in nuclear structure physics which solves an eigenvalue problem of the nuclear Hamiltonian in a multiphonon basis. Here we present extension of EMPM suitable for single Lambda hypernuclei. The basic idea is to diagonalize the hypernuclear Hamiltonian in a basis of states which includes NΛ TDA phonons as well as NΛ TDA coupled to TDA excitations of the nuclear core.

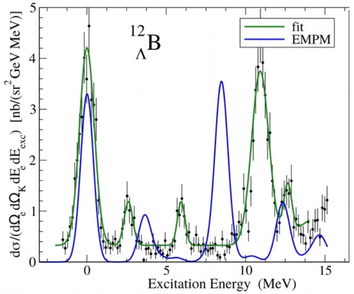
OBDME: The hypernuclear wave functions calculated either by NΛ TDA or EMPM serve us to determine OBDME. This allows us to study cross section of electroproduction of hypernuclei.

Results:

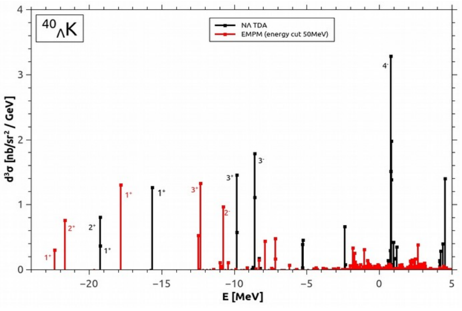
We apply hypernuclear Hamiltonian which includes chiral **NN + NNN** interaction NNLO$_{sat}$ [Phys. Rev. C 91, 051301(R), (2015)] and an effective **LambdaN** potential obtained as G-matrix applied on the Nijmegen YN interaction (Prog. Theor. Phys. Suppl. 117, 361 (1994)). The parameter of G-matrix – Fermi momentum k_F – was chosen in order to obtain realistic low lying energy spectrum of $^{12}_{\Lambda}$B within EMPM.



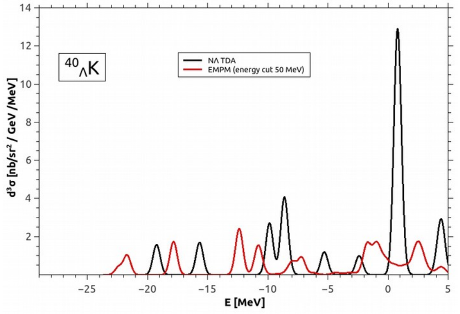
Cross section of electroproduction of $^{12}_{\Lambda}$B calculated within NΛ TDA and EMPM. EMPM shifts spectrum down in energy, quench the amplitude of main peaks and shows richer spectrum of states than NΛ TDA.



Cross section of electroproduction of $^{12}_{\Lambda}$B calculated within EMPM (smoothed by an Gaussian function) and compared to the fit of the experimental data.



Cross section of electroproduction of $^{40}_{\Lambda}$K calculated within NΛ TDA and EMPM (energy cut 50 MeV). EMPM shows the effect of multifragmentation.



The same as Fig. on the left. The cross sections are smoothed by an Gaussian function.