# Microscopic Effective Interactions for the Nuclear Shell Model

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The interacting shell model [1] is a modern many-body method used in nuclear structure calculations. Within the shell-model framework, the eigenproblem for a microscopic Hamiltonian is solved by exact diagonalization of the Hamiltonian matrix constructed in a spherically-symmetric many-body basis (for example, a harmonic oscillator basis). The basis dimensions, however, grow very rapidly with increasing atomic number *A*. For nuclei with $A > 20$, only a few valence nucleons can be treated as active particles interacting with each other in a truncated Hilbert space, consisted of one or two oscillator shells outside a closed-shell core. Because of such a highly limited model space, the interaction between valence nucleons should be an effective interaction and not a bare nucleon-nucleon interaction as between nucleons moving in the full Hilbert space. When phenomenological effective interactions are used, the shell model is known to provide excellent description of excitation spectra and transitions at low energies. At the same time, construction of accurate microscopic effective interactions from the bare nucleon-nucleon potential is still a challenge. Folded diagram theory [2] is a well-developed method based on perturbation theory for derivation of microscopic effective interactions. Within this framework, we have constructed new microscopic effective interactions from the $N^3LO$, CD-Bonn and Daejeon16 nucleon-nucleon potentials. Effective single-particle energies, oxygen isotope ground-state energies and spectra of selected *sd*-shell nuclei are studied using the newly derived microscopic interactions and compared with the results obtained from a phenomenological interaction USDB.

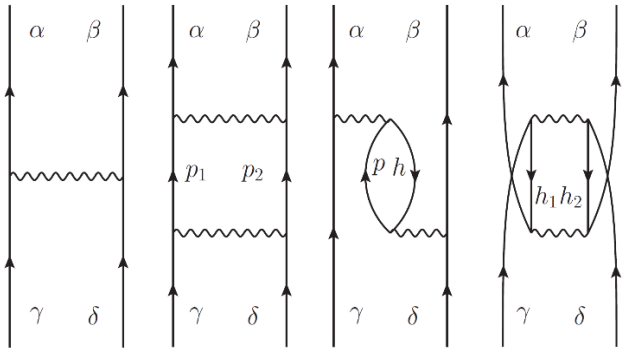


Figure 1: First and second order Feynman-Goldstone diagrams in the folded diagram theory.

***References:***

[1] E. Caurier, G. Martínez-Pinedo, F. Nowacki, A. Poves and A. P. Zuker, Rev. Mod. Phys. 77, 427 (2005).

[2] T. T. S. Kuo and E. Osnes, *Folded-Diagram Theory of the Effective Interaction in Atomic Nuclei*, Springer Lecture Notes in Physics, (Springer, Berlin, 1990) Vol. 364.