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A quantum optimization algorithm for deriving e ective shell model Hamiltonians

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In the recent years, theoretical methods for calculating the two body matrix elements of shell-model e ective Hamiltonians starting from realistic interactions have evolved considerably. However, these methods, usually rooted in the framework of many-body perturbation theory, present several sources of inaccuracies: 1) the convergence of the perturbation expansion; 2) the oscillator basis used for matrix elements and energy denominators is an approximation; 3) three-body force are required.
Thus, to obtain realistic wave functions there is a need to modify the e ective interactions based on constraints from experimental data, or, alternatively, to determine them from scratch. Usually, these kind of analysis are performed resorting to least squares approach. Notable examples are the Cohen and Kurath [1] and the USD interactions [2] for the p- and sd-shell nuclei, respectively. However, this approach starts to be demanding once the dimension of the model space and/or the number of experimental data increases.
Here, we propose an alternative approach, to our knowledge never used for this purpose, based on the use of an evolutionary algorithm, the Genetic Algorithm (GA). It is inspired by the process of natural selection and commonly used to generate high-quality solutions to optimization and search problems by relying on biologically inspired operators such as mutation, crossover and selection. The quantum version of the GA algorithm for the binary encoding case can be found in Ref. [3]. Its quantum version for the real encoding case is under development and we are using the derivation of an effective interaction for p-shell nuclei as possible application. I will discuss preliminary results obtained on a classical computer demonstrating the possibility to use GA to derive e ective shell-model Hamiltonians capable to give a description of p-shell nuclei better or comparable to well-established Hamiltonians like the Cohen and Kurath one.

[1] S. Cohen and D. Kurath, Nuclear Physics 73 (1965)

[2] B. A. Brown and B. H. Wildenthal, Annu. Rev. Nucl. Part. Sci. 38, 29 (1988).

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