Quantum computing algorithm for shell model states

B. Maheshwari[1*] and P. D. Stevenson[2]
[1] *Grand Accélérateur National d'Ions Lourds, CEA/DSM-CNRS/IN2P3, Bvd Henri Becquerel, BP 55027, F-14076 Caen, France*
[2] *Department of Physics, University of Surrey, Guildford, GU2 7XH, United Kingdom*

The shell model stands as the backbone of nuclear physics, successfully explaining most nuclear phenomena. However, its practical applicability is often constrained by the dimensional limitations of its Hamiltonian, even with high-performance classical computers. Quantum computing presents a promising pathway to overcome these limitations. With this in mind, we simulate a quantum algorithm tailored for a simple shell model problem within a single-j orbital, utlizing the hybrid approach of encoding anstaz-driven quantum circuits with the variational quantum eigensolver framework [1]. The two-body interaction matrix elements are transformed into m-scheme and subsequently mapped onto a qubit-based representation. The simulation further attempts to calculate the transition overlaps between the low-lying states for a two-particle system, with a focus on configurations up to seniority 2. These preliminary results mark a step toward leveraging the quantum algorithms for the study of nuclear isomeric states, particularly the seniority isomers [2]. Early findings will be presented to illustrate the method's potential.

[1] B. Bhoy and P. Stevenson, New Journal of Physics *26*, 075001 (2024).
[2] A. K. Jain, B. Maheshwari and A. Goel, *Nuclear Isomers- A Primer*, Springer Nature (2021).

*The author BM gratefully acknowledges the financial support from the HORIZON-MSCA-2023-PF-01 project, ISOON, under grant number 101150471.