NUCLEAR SHELL MODEL FROM FIRST PRINCIPLES

Prof Bruce R Barrett[1], Prof Erdal Dikmen[2], Prof James P Vary[3]

[1]Department of Physics, University of Arizona
[2]Suleyman Demirel University
[3]Iowa State University

For more than 60 years nuclear physicists have tried to derive microscopically the effective two-body interactions, which are needed for performing standard shell model (SSM) calculations for atomic nuclei. Phenomenologically, these residual two-body matrix elements (TBMEs) are obtained by fits to selected experimental data in a single major shell. Using a formalism based on the No Core Shell Model (NCSM), we have succeeded in deriving microscopically the core energy, the single-particle energies (SPEs) and the TBMEs that are the input to SSM calculations. Our theory has three major elements:
(1) perform an Okubo-Lee-Suzuki (OLS) transformation on the input realistic interaction for a no-core basis, (2) perform NCSM calculations on near-closed shell nuclei, and (3) perform a second OLS transformation into a single major shell, e.g., the sd-shell. This allows one to separate the many-body matrix elements into an "inert" core part, SPEs and TBMEs. We demonstrate the theory on the nuclei which make up the Fluorine isotopic chain. We also compare our findings with similar results obtained using the In-Medium Similarity Group method, in order to gain a better understanding of the A-dependence as well as the agreement with other microscopic approaches. We also focus on the inferred role of three-nucleon interactions on the derived SPEs and the multipole structure of our residual TBMEs.