Partial dynamical symmetries in the shell model

Supervisor: Piet Van Isacker [isacker@ganil.fr, (33) (0)2 31 45 45 65]

Field: nuclear physics (theory)

Prerequisites: quantum mechanics, mathematical methods in physics, nuclear physics

Description

In the shell model neutrons and protons are placed in a set of orbitals that are available to the valence nucleons of a given nucleus. A major problem encountered in this approach is the rapid increase of the dimension D of the Hilbert space of configurations with the number of valence nucleons and/or the available valence orbitals, leading to an eigenvalue problem that requires the diagonalisation of a huge D x D matrix. It is therefore of interest to propose models that do not require a numerical diagonalisation and that can be solved analytically through symmetry-based or group-theoretical methods. In nuclear structure, two classes of such models are known since the 1940s and 1950s: Racah's SU(2) model, based on the pairing interaction between like nucleons, and Elliott's SU(3) model, based on the quadrupole interaction between neutrons and protons. Both can be considered as an application of the concept of dynamical symmetry or spectrum generating algebra. The hallmark of a dynamical symmetry is the property that *all* eigenstates are solvable.

The concept of dynamical symmetry can be considerably enlarged by making it partial. While different versions of partiality exist, the generalisation of interest in this project is one where *some* eigenstates are solvable, typically those at low energy. Over the last three decades partial dynamical symmetry has been mainly applied in the context of the interacting boson model and it is the purpose of the present project to explore its application in the context of the shell model. Specifically, the SU(3) dynamical symmetry of Elliott will be taken as a starting point and additional interactions will be considered, which leave *some* of the SU(3) states unaltered while mixing others. This construction will be carried out for the p shell (applicable to nuclei from ^{4}He to ^{16}O) and, if time permits, for the sd shell (from ^{16}O to ^{40}Ca).

Aims of the project

- Introduction to the shell-model problem of neutrons and protons in a harmonic-oscillator shell.
- Introduction to the notions of symmetry and dynamical symmetry with the example of SU(3) in the nuclear shell model.
- Construction of shell-model interactions with a partial dynamical SU(3) symmetry in the p shell and, if time permits, in the sd shell.
- Numerical calculations with interactions with a partial dynamical SU(3) symmetry in the p shell and, if time permits, in the sd shell.