# Mid-shell nuclei and the Berry phase

*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 this project the problem of neutrons and/or protons placed in a single-*j* shell and interacting through a two-body force is considered. It is well known that, if there is only one kind of nucleon, either neutrons *or* protons, eigenstates of the Hamiltonian are characterised by a quantum number called seniority, which counts the number of nucleons not in pairs coupled to angular momentum *J*=0. This property is exactly valid for the pairing interaction [1] and, to a good approximation, holds also for a realistic interaction between identical nucleons [2]. It was shown recently [3] that seniority conservation in semi-magic nuclei can be explained on the basis of a general mechanism, namely a Berry phase [4] associated with particle-hole conjugation, which becomes observable in mid-shell nuclei.

It is also known that the neutron-proton interaction breaks seniority, which therefore is not expected to be a good quantum number in systems with neutrons *and* protons. Nevertheless, the Berry-phase mechanism is universal and not subject to the limitation of a one-component system. The purpose of the project is to investigate the observable consequences, if any, of the particle-hole Berry phase in systems with neutrons *and* protons at mid-shell, i.e. for two neutrons and two protons in a *j*=3/2 shell, three neutrons and three protons in a *j*=5/2 shell, etc.

*Outline*
- Introduction to the shell model with neutrons and protons in a single-*j* shell.
- Introduction to seniority in systems with only one kind of nucleon.
- Study of seniority conservation in systems with either neutrons or protons at mid-shell and of their M1 and E2 decay properties.
- Systematic study of mid-shell systems with neutrons and protons for *j*=3/2, 5/2, 7/2 and 9/2.

[1] G. Racah, *Theory of Complex Spectra III,* Phys. Rev. **63** (1943) 367.
[2] I. Talmi, *Simple Models of Complex Nuclei* (Harwood, Chur, 1993).
[3] J.J. Valiente-Dobón et al., to be published.
[4] M.V. Berry, *Quantal Phase Factors Accompanying Adiabatic Changes*, Proc. Roy. Soc. A **392** (1984) 45.