Negative parity intruder states in sd shell nuclei: a complete $1\hbar\omega$ shell model description

M. BOUHELAL [1,2], F. HAAS [1], E. CAURIER [1], F. NOWACKI [1], A BOULDJEDRI [2]
[1] *IPHC, CNRS/IN2P3, Université Louis Pasteur, F-67037 Strasbourg Cedex 2, France*
[2] *Département de Physique, Faculté des Sciences, Université de Batna, Batna, Algérie*

Abstract:

The nuclear structure of the sd shell nuclei has been well studied experimentally near the stability line and more recently the interest has been focused on the neutron rich species. The normal positive parity states are well described using the USD interaction [1] in the $0\hbar\omega$ sd shell space with an ^{16}O core. This interaction has recently been updated and the obtained new Hamiltonians are called USDA and USDB [1]. The experimental energy spectra show the existence, in addition of the normal states, of a set of negative parity states named "intruder states", resulting from the excitation of one nucleon from the p shell to sd shell for nuclei near ^{16}O or from the sd to the fp shell for nuclei close to ^{40}Ca. In the middle of the sd shell there is a competition between the two types of excitation for the intruders. No unified description of the negative parity states exists.

To study the intruder states we must enlarge the model space from the sd space (^{16}O core) to the full p-sd-pf space (^{4}He core). This requires the construction of a new interaction compatible with this extended shell model space. Such a procedure is now possible due to the today increased computational power. We have thus developed for the first time a $1\hbar\omega$ interaction called PSDPFB, which has five distinctive parts: p, sd and fp shells and cross p-sd and sd-pf shells. The fixed three interactions for the p, sd and fp shells are respectively: CK [2], USDB [1] and IOKIN [3], the latter contains also the sd-pf two body matrix elements, the p-sd interaction is taken to be the PSDT interaction from Ref. [4]. We have modified the cross p-sd and sd-pf shells contributions to reproduce the energy evolution of the negative parity states of different spins throughout the complete sd shell.

We have used this PSDPFB interaction in order to calculate the energy and wave function evolution for the intruders with 0^- to 6^- for nuclei with N=Z and $1/2^-$ to $13/2^-$ for nuclei with N=Z+1 throughout the sd shell. We will also present some results obtained for neutron rich Si, P and S isotopes. A comparison with the existing experimental data shows good agreement and gives thus credit to our proposed new interaction to describe intruder states in sd shell nuclei.

[1] B. A. Brown and W. A. Richter, Phys. Rev. C74 (2006) 034315 and references therein.
[2] S. Cohen and D. Kurath, Nucl. Phys. 73 (1965)1; A101 (1967) 1.
[3] S. Nummela et al., Phys. Rev. C63 (2001) 044316.
[4] E. K. Warburton and B.A. Brown, Phys. Rev. C46 (1992) 923.