Shell Model Calculations in the Lead Region ◇

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To confirm the concept of homology as spectroscopic tool to identify spin and parity of a large number of levels [1] shell model calculations have been performed for ^{206}Pb and ^{205}Tl based on the usual two-body Hamiltonian

$$H \;=\; \sum_i \epsilon_i a_i^\dagger a_i \;+\; \sum_{i>j=1,k>l=1} V_{ijkl} a_i^\dagger a_j^\dagger a_k a_l$$

using the OXBASH [2] code. The core has been assumed to be ^{208}Pb and ϵ_i are the single-hole energies of the proton (neutron)-hole nucleus ^{207}Tl (^{207}Pb), and the single-particle energies of the neutron-particle nucleus ^{209}Pb. The two-body matrix elements $V_{ijkl} = \langle ij\,|V|\,kl\rangle$ have been calculated from MSDI (Modified Surface Delta Interaction). The configuration space has been assumed of the form $(3h)$ for ^{205}Tl, and a mixing of $(2h)$ and $(3h-1p)$ for ^{206}Pb, with a proton particle in the $h_{9/2}$ shell.

About the nature of the states in ^{205}Tl, the $1/2^+$ and $3/2^+$ states display a predominant single-hole proton character, the total probability of having a hole in the $s_{1/2}$ and in the $d_{3/2}$ orbitals, respectively, being in both cases larger than 70%. This is not the case of $5/2^+$ and $7/2^+$ states. For the $5/2^+$ the percentage of $d_{5/2}$ single-hole only amounts to approximately 10%, the main component still being the $s_{1/2}$ hole ($\sim 67\%$) with recoupling of the neutron holes to non-zero angular momentum.

In spite of the large configuration mixing, multiplets can be sorted out in the ^{206}Pb spectrum, fig. 1, which can be put in connection with parent states in ^{205}Tl, with spectator role of the $h_{9/2}$ proton orbital. In most cases the states of each multiplet display wave functions which are very similar among them, and, more important, similar to the wave function of the parent state in ^{205}Tl. And this is not only the case of the multiplets homologous to the rather pure $1/2^+$ and $3/2^+$ states, but also in the case of the largely mixed $5/2^+$ and $7/2^+$.

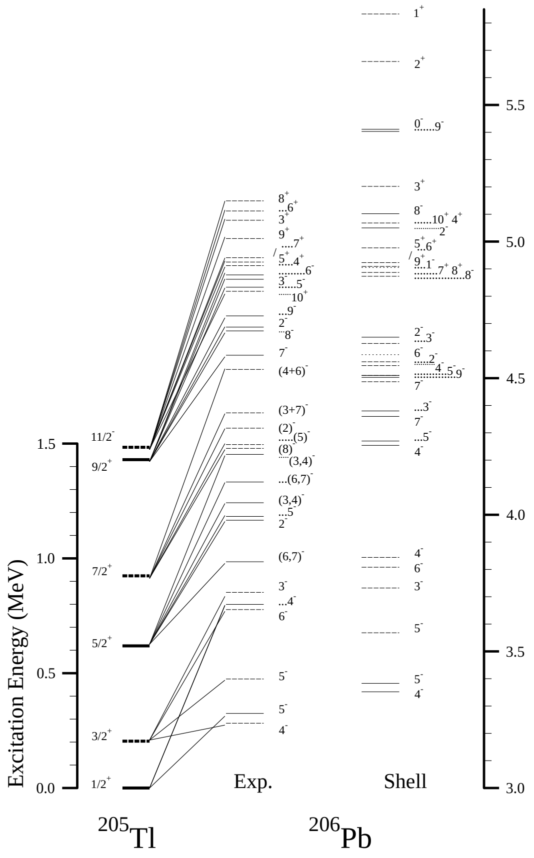

Fig. 1: Comparison of experimental and theoretical energy spectra for ^{206}Pb. Solid and dashed lines identify homologous levels in ^{205}Tl and ^{206}Pb.

References

[1] P. Guazzoni et al., Report INFN/BE-95/04 (1995)
[2] A. Etchegoyen et al., MSU-NSCL Report 524 (1985)

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