Tensor force and odd-even nuclei

G. Co' [a] [b] and Viviana De Donno [a] and M. Anguiano [c] and A. M. Lallena [c]

[a]Dipartimento di Matematica e Fisica “E. De Giorgi”, Università del Salento, Italy

[b]Istituto Nazionale di Fisica Nucleare sez. di Lecce, Italy

[c]Departamento de Física Atómica, Molecular y Nuclear, Universidad de Granada, Granada, SPAIN

We have investigated the observables of even-odd nuclei with one nucleon more, or less, than the doubly magic nuclei. The computational scheme of our approach is outlined by the diagrams of Fig. 1. The external probe, represented by the wiggly line, interacts with the odd-even nucleus. This is described by considering the interaction with the single unpaired nucleon, the diagram A, plus two terms which take care of the interaction with the nucleons of the doubly magic core correlated by the strong interaction, represented by the dashed lines. These polarisations of the core, the doubly magic nucleus, are considered in terms of Radom Phase Approximation (RPA) theory as indicated in [1]. In our approach, we use a unique and universal interaction to generate the single particle basis by means of a Hartree-Fock calculation and also the core polarisation in the RPA framework. The interaction used in our approach [2] includes also tensor terms and the main physical interest of this work is to study if the observables of odd-even nuclei are particularly sensitive to these terms of the interaction.

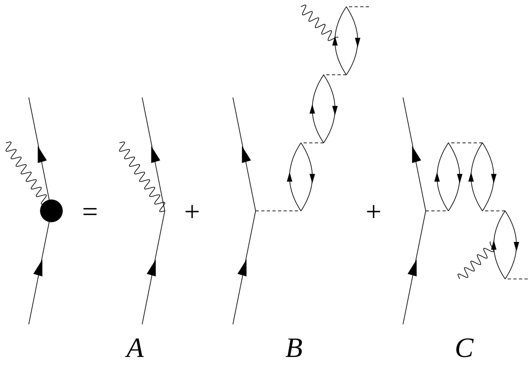

Figure 1.

We show in Tab. 1 some results regarding the magnetic dipole moments for some states of nuclei around the ^{208}Pb doubly magic nucleus. The contribution of the A diagram is given by the textbook results known as Schmidt values [3]

$$\langle \mu \rangle = \left[g_l (j - \frac{1}{2}) + \frac{1}{2} g_s \right] \mu_N \qquad \text{for} \qquad j = l + \frac{1}{2} \tag{1}$$

$$\langle \mu \rangle = \left[g_l \frac{j(j+\frac{3}{2})}{j+1} - \frac{1}{2} \frac{1}{j+1} g_s \right] \mu_N \qquad \text{for} \qquad j = l - \frac{1}{2} \tag{2}$$

In the above equations μ_N is the nuclear magneton, $g_l = 1$ for proton and $g_l = 0$ for neutron, $g_s = 2.79$ for proton and $g_s = -1.91$ for neutron. We have indicated with j the angular momentum of the state of the odd-even nucleus, which corresponds to the angular momentum of the single particle state of the unpaired nucleon.

The results of the column labelled as D1S has been obtained with a finite-range interaction without tensor term, while the results of the D1ST2 column have been obtained with the tensor interaction. The experimental values are taken from the compilation of Ref. [4].

nucleus	state	Schmidt	D1S	D1ST2	exp
^{209}Bi	$1h_{9/2}$	2.634	3.219	3.085	4.08
^{209}Bi	$1i_{13/2}$	8.793	8.149	8.220	8.07 ± 0.19
^{209}Bi	$1i_{11/2}$	3.560	4.120	4.076	
^{207}Tl	$2d_{5/2}$	4.793	4.244	4.348	
^{207}Tl	$2d_{3/2}$	0.124	0.423	0.353	
^{209}Pb	$2g_{9/2}$	-1.913	-1.531	-1.588	-1.33 ± 0.06
^{209}Pb	$2g_{7/2}$	1.488	1.196	1.241	
^{207}Pb	$3p_{3/2}$	-1.913	-1.519	-1.608	
^{207}Pb	$3p_{1/2}$	0.630	0.538	0.548	0.59

Table 1

Magnetic dipole moments for some states of nuclei around the ^{208}Pb nucleus in nuclear magnetons units.

The values obtained by considering the core polarisation are rather different from the Schmidt values. It is well known [3] that, for odd-proton nuclei the Schmidt values overestimate the experimental values for stretched states, $j = l + 1/2$, and underestimate those for jack-knife states, $j = l - 1/2$. The situation is opposite for the odd-neutron states. All the results obtained by considering the core polarisation contribute to increase the agreement with the data.

The role of the tensor force is less evident. For the odd-neutron nuclei, the lead isotopes, the tensor force produces rather small effects, i. e. of the order of few percent. The general trend indicates a small lowering of the magnetic moment values for stretched states, and an increase for the jack-knife states. The situation is different for the proton-odd nuclei. In this case the effects of the tensor are larger and show a regularity in their behaviour. We observe an increase of the magnetic dipole moments for stretched states and a decrease for the jack-knife states.

At the moment we are extending these type of calculations also to nuclei around the ^{16}O, ^{40}Ca, ^{48}Ca, ^{90}Zr, ^{116}Sn doubly magic nuclei, to test the consistency of our findings also in other regions of the nuclear chart.

REFERENCES

1. R. Bauer, J. Speth, V. Klemt, P. Ring, E. Werner, T. Yamazaki, Nucl. Phys. A 209 (1973) 535.
2. M. Grasso, M. Anguiano, Phys. Rev. C88 (2013) 054328.
3. K. S. Krane, Introductory Nuclear Physics, Wiley, New York (1988).
4. N.J. Stone, Atomic Data and Nuclear Data Tables 90 (2005) 75.