The ^{45}Sc($\vec{\mathrm{p}}, \alpha$)^{42}Ca Reaction and the Corresponding Homologous States

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In order to investigate the spectator role of the 1f$_{7/2}$ unpaired proton outside the Z=20 closed shell in ^{45}Sc nucleus we have measured the ^{45}Sc($\vec{p}, \alpha$)^{42}Ca reaction at high resolution. The study of the ^{44}Ca($\vec{p}, \alpha$)^{41}K [1] and ^{45}Sc($\vec{p}, \alpha$)^{42}Ca reactions at the same proton incident energy and in the same experimental conditions allows for the identification, in the neighbouring systems ^{41}K and ^{42}Ca, of corresponding homologous states. This occurrence of homologous states implies the persistence of preferred structures that survive after the addition of the 1f$_{7/2}$ proton to the ^{44}Ca nucleus.

The spin and parity assignment to the homologous levels populated in the daughter reaction ^{45}Sc($\vec{p}, \alpha$)^{42}Ca is carried out following our methodology based on the homology concept [2]. In such a way the multiplet of states of ^{42}Ca homologous to the $\frac{3}{2}^+$ ground state of ^{41}K has been identified. The weak coupling model foresees in ^{42}Ca a quartet of states homologous to the parent state ^{41}K $\frac{3}{2}^+$ G.S., with $J^\pi = 2^-, 3^-, 4^-, 5^-$. We have identified the following levels: 3.954 MeV, $J^\pi = 4^-$, 4.100 MeV, $J^\pi = 5^-$, and 4.117 MeV, $J^\pi = 3^-$, while the 2^- level is missing.

In Fig.1 the comparison between the measured $\sigma(\theta)$ and A$_y(\theta)$ for the transitions to the multiplet of ^{42}Ca states (dots) homologous to the G.S. $\frac{3}{2}^+$ of ^{41}K is presented. The last measured cross section is scaled for each level by the proper factor $\frac{(2J_i+1)}{\Sigma_i(2J_i+1)}$ (solid line).

Exploratory shell model calculations, involving one hole excitation from the $d_{3/2}$ shell to the full fp shell, have been performed and reproduce some features of our experimental results. Calculations have been carried out with the code ANTOINE [3] and the interaction *spdf.sm* [4] for both ^{41}K and ^{42}Ca. In the case of ^{41}K the dominant configuration of the $\frac{3}{2}^+$ G.S. is $\pi(d_{3/2}^{-1})\nu(f_{7/2}^2)$. For ^{42}Ca we have calculated the low spin negative parity states $J^\pi = 2^-, 3^-, 4^-, 5^-$. The relative excitation energies of the $3^-, 4^-, 5^-$ states are in good agreement with the experimental data. The dominant configuration of these states is $\pi(f_{7/2}^1, d_{3/2}^{-1})\nu(f_{7/2}^2)$ as would be expected in the hypothesis of homologous states. The 2^- state, however, has a very different structure, as shown in Table 1. This is in agreement with the fact that this state is not populated in the ^{45}Sc($\vec{p}, \alpha$)^{42}Ca reaction.

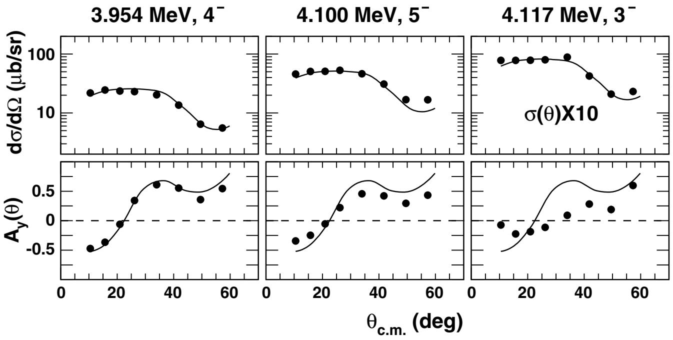

Fig. 1: $\sigma(\theta)$ and A$_y(\theta)$ for the transitions to the multiplet of ^{42}Ca states homologous to the G.S. $\frac{3}{2}^+$ of ^{41}K (see text).

References

[1] P. Guazzoni *et al.*, this report, p.6
[2] P. Guazzoni *et al.*, Z. Phys. **A356** (1997) 381
[3] E. Caurier Computer code ANTOINE, Strasbourg (1989-2002)
[4] S. Nummela *et al.*, Phys.Rev. **C63** (2001) 044316

neutron							proton							total
p1	f5	p3	f7	d3	s1	d5	p1	f5	p3	f7	d3	s1	d5	%
^{41}K G.S. $3/2^+$ Parent State														
0	0	0	2	4	2	6	0	0	0	0	3	2	6	**87.8**
0	0	1	1	4	2	6	0	0	0	0	3	2	6	1.4
0	0	2	0	4	2	6	0	0	0	0	3	2	6	3.2
0	2	0	0	4	2	6	0	0	0	0	3	2	6	2.9
^{42}Ca 3^- Total Homologous 77.6 %														
0	0	0	2	4	2	6	0	0	0	1	3	2	6	**64.7**
0	0	1	1	4	2	6	0	0	0	1	3	2	6	8.5
0	0	2	0	4	2	6	0	0	0	1	3	2	6	2.5
0	2	0	0	4	2	6	0	0	0	1	3	2	6	1.9
^{42}Ca 4_1^- Total Homologous 82.4 %														
0	0	0	2	4	2	6	0	0	0	1	3	2	6	**74.1**
0	0	1	1	4	2	6	0	0	0	1	3	2	6	3.8
0	0	2	0	4	2	6	0	0	0	1	3	2	6	2.3
0	2	0	0	4	2	6	0	0	0	1	3	2	6	2.2
^{42}Ca 5_1^- Total Homologous 78.4 %														
0	0	0	2	4	2	6	0	0	0	1	3	2	6	**68.9**
0	0	1	1	4	2	6	0	0	0	1	3	2	6	4.6
0	0	2	0	4	2	6	0	0	0	1	3	2	6	2.6
0	2	0	0	4	2	6	0	0	0	1	3	2	6	2.3
^{42}Ca 2_1^- Not Homologous														
0	0	0	2	4	2	6	0	0	0	1	3	2	6	29.4
0	0	1	1	4	2	6	0	0	0	1	3	2	6	18.6
0	0	2	0	4	2	6	0	0	0	1	3	2	6	1.9
0	2	0	0	4	2	6	0	0	0	1	3	2	6	——

Table 1: Main components of the wave functions of the different states