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SPECTROSCOPY OF ^{88}Y BY MEANS OF THE ^{91}Zr $(\vec{p}, \alpha)^{88}$Y REACTION AT 22MeV

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SPECTROSCOPY OF ^{88}Y BY MEANS OF THE ^{91}Zr ($\vec{p}$, α)^{88}Y REACTION AT 22MeV

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Abstract. This contribution presents high resolution results for the ^{91}Zr($\vec{p},\alpha$)^{88}Y. The homology concept allows to find a correspondence between the observed multiplets of highly excited states in ^{88}Y and the appertaining parent states in ^{87}Y. Therefore spin and parity values can be attributed to the states of the multiplets through comparison of different experimental results.

In low resolution experiments (1), it has been shown that the spectra of α-particles emitted in (p,α) reactions, induced on target nuclei having one unpaired nucleon outside a magic shell, display distinctive features which indicate that this last, slightly bound nucleon, acts as a spectator in the process. These features are: 1) weak population of residual nucleus levels below an excitation energy, strictly related to the energy gap, in the nucleon state spacing at the filling of the magic shell 2) excitation of homologous states (i.e. of states with a close structural relationship) of residual nuclei from (p,α) on adjacent target nuclei, one *m a g i c* with a magic neutron and/or proton shell (parent), and the other, *n e a r - m a g i c*, with one more nucleon outside the magic shell (son).

To study the spectator role of the unpaired nucleon in different mass regions, ^{208}Pb($\vec{p},\alpha$)^{205}Tl (2), ^{209}Bi($\vec{p},\alpha$)^{206}Pb (3) and ^{90,91}Zr($\vec{p},\alpha$)^{87,88}Y reactions were studied at 22 MeV with the Munich Tandem, using the polarized ion source, the Q3D magnetic spectrograph and the position and angle resolving light ion detector. In fig.1 the 20° energy spectra for the reactions ^{90}Zr($\vec{p},\alpha$)^{87}Y up to E_x= 3 MeV and of ^{91}Zr($\vec{p},\alpha$)^{88}Y up to E_x=5.2 MeV are reported. The ^{88}Y states, shown in the middle, correspond to the coupling of the 51^{st} $2d_{\frac{5}{2}}$ neutron in ^{91}Zr with the configurations excited in ^{87}Y.

In the case of weak coupling between the parent state and the spectator proton or neutron it is expected: a) the angular distributions of cross sections

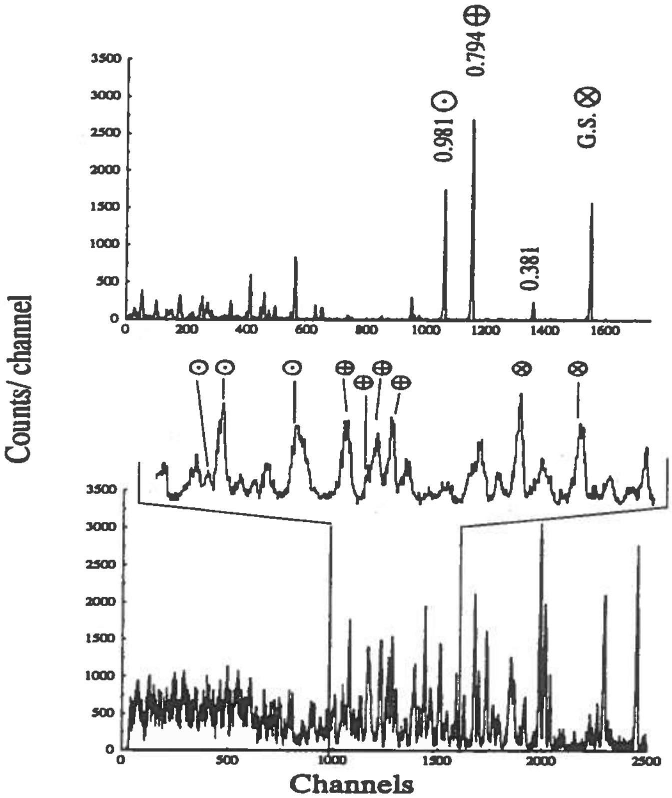

FIGURE 1: Energy spectra of α particles measured at 20^o for the ^{90}Zr(p,α)^{87}Y (up) and ^{91}Zr(p,α)^{88}Y (down) reactions. In the middle levels of ^{88}Y homologous to the lowest energy states of ^{87}Y are presented in enlarged scale.

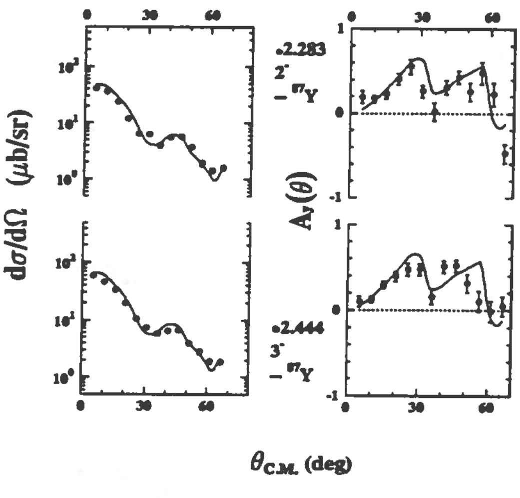

FIGURE 2: Comparison of the experimental cross sections and analyzing powers for population of the doublet of levels of ^{88}Y (solid points) homologous to the $1/2^-$ g.s. of ^{87}Y with the experimental cross sections and analyzing powers for population of the parent state (solid lines).

TABLE 1: Energies, spin and parity of homologous states

^{87}Y		^{88}Y		
E_{exc}	J^π	E_{exc}	J^π	$J^\pi{}_{ad}$
g.s.	$\frac{1}{2}^-$	2.283	2^-	
		2.244	3^-	(10^+)
0.794	$\frac{5}{2}^-$	2.722	3^-	$3^+,4^+,5^+$
		2.764	2^-	
		2.787	1^-	
		2.823	4^-	
		3.150	$(^-)$	
		3.207	$(^-)$	
0.982	$\frac{3}{2}^-$	2.957	2^-	
		2.997	$(^-)$	
		3.023	$(^-)$	
		3.049	$(^-)$	
		3.093	3^-	
		3.122	1^-	

and analyzing powers for transitions to homologous states to be very similar in shape, because the processes exciting these states are essentially the same; b) the differential cross section for the population of a parent state to be approximately equal in magnitude to the sum of the cross sections of the transition to the multiplet of homologous son states which corresponds to the given parent state; c) the relative cross section for the population of a homologous son state with spin J in a given multiplet to be proportional to $(2J+1)$.

In fig.s 2,3,4 the comparison between the measured $\sigma(\theta)$ and $A_y(\theta)$ for the transitions to the various multiplets of homologous states in ^{88}Y, scaled for each level i by the factor $\frac{2J_i+1}{\Sigma_i(2J_i+1)}$ and the angular distributions of the cross sections and asymmetries for the transitions to the corresponding parent levels in ^{87}Y are shown.

In Table 1 multiplets of homologous states we identified are reported. The levels, for which only parity is indicated, were identified on the hypothesis of a possible fragmentation of highest spin levels.

The cumulative cross section and asymmetry for the doublet of levels homologous to the $\frac{1}{2}^-$ g.s. of ^{87}Y are in perfect agreement with those relative to the g.s. of ^{87}Y either in absolute value, and in shape.

In the case of the $\frac{5}{2}^-$ 0.794 MeV parent level, we have identified only a quartet, instead of the sextet of son states : are missing the 0^- and 5^- levels.

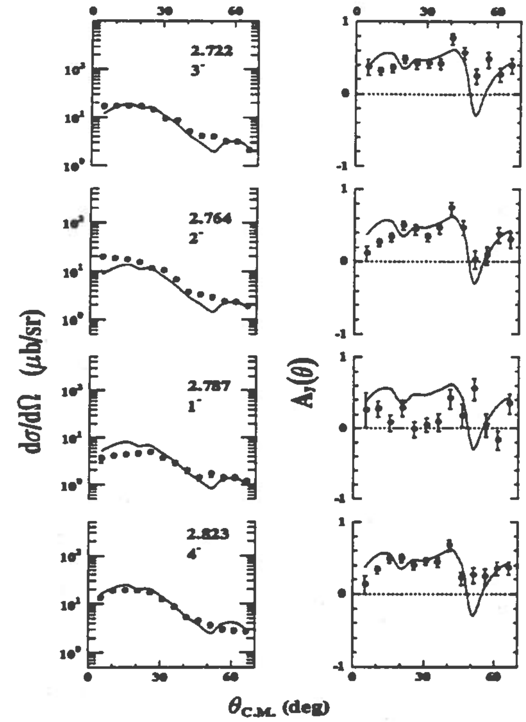

FIGURE 3: Comparison of the experimental cross sections and analyzing powers for population of four levels of ^{88}Y (solid points) considered homologous to the $5/2^-$ 0.794 MeV of ^{87}Y level with the experimental cross sections and analyzing powers for population of the parent state (solid lines).

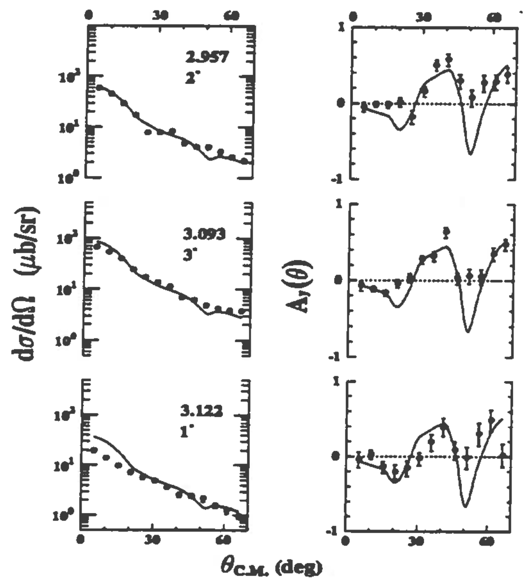

FIGURE 4: Comparison of the experimental cross sections and analyzing powers for population of three levels of ^{88}Y (solid points) considered homologous to the $3/2^-$ 0.982 MeV of ^{87}Y level with the experimental cross sections and analyzing powers for population of the parent state (solid lines).

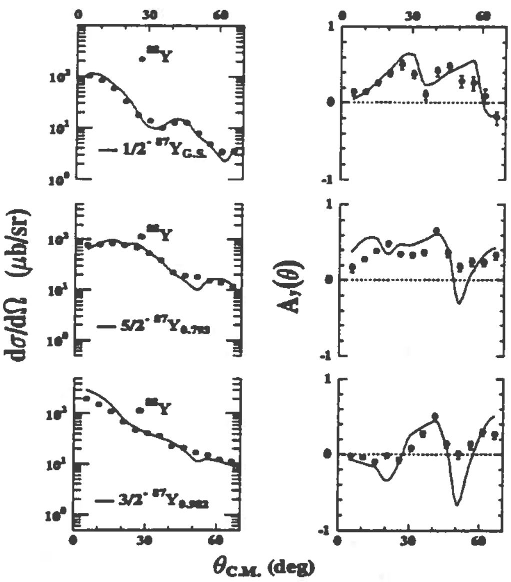

FIGURE 5: Cumulative cross sections and analyzing powers for population of multiplets of states of ^{88}Y (solid points) homologous to the low-lying parent states of ^{87}Y, including the fragmentated level contributions, compared with the cross sections and analyzing powers for population of these ^{88}Y states (solid lines).

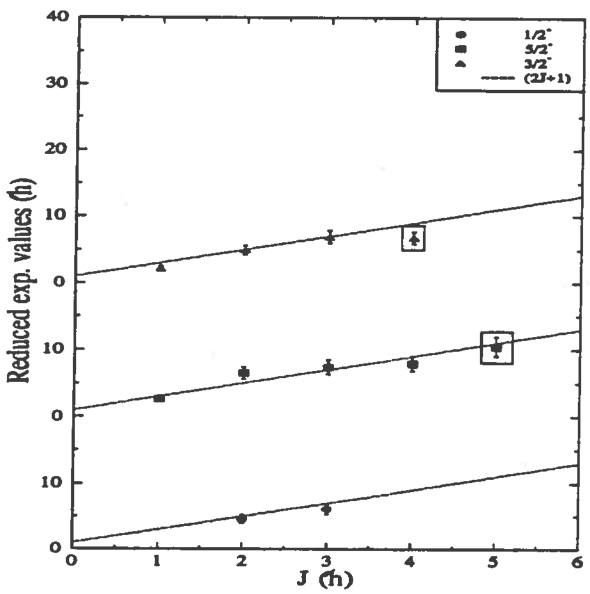

FIGURE 6: Reduced experimental values $\frac{\sigma(J_i)_{^{88}Y}}{\sigma_{^{87}Y}}\Sigma_i(2J_i+1)$ for the multiplets of states (solid points) homologous to the ^{87}Y parent states reported as a function of J and compared with the straight line (2J+1) predicted by the weak coupling model (dashed lines). The two surrounded points correspond to the sum of the different branched levels.

The cross section of the 0^- member of the multiplet is expected to be very small and consequently its observation is difficult. On the contrary the cross section of the 5^- member of the same multiplet is expected to be about 30% of the cumulative cross section of the multiplet of states homologous to the $\frac{5}{2}^-$ 0.794 MeV parent level of ^{87}Y. There is no experimental evidence for this high cross section, whereas for the levels of ^{88}Y at 3.150 MeV and 3.207 MeV the shape of the differential cross sections and of the asymmetries fits very well the corresponding ones of the parent state.

In the case of the $\frac{3}{2}^-$ 0.982 MeV parent level, we have identified only a triplet, instead of the quartet of son states. The 4^- level of this multiplet is missing: its cross section is expected to be about 38% of the cumulative cross section for this multiplet. There is no experimental evidence for this high cross section, while for the levels of ^{88}Y at 2.997MeV, 3.023 MeV and 3.049 MeV the shape of the angular cross sections and of the asymmetries is reproduced by the differential cross section and asymmetry for the excitation of the 0.982 MeV parent state in ^{87}Y. If the previously discussed levels are included in the cumulative cross section of the proper multiplet, the parent state angular distributions of cross section and asymmetry are practically reproduced (fig.5). So it seems that the highest spin homologous son levels are fragmented.

In fig.6 the quantity $\frac{\sigma(J_i)_{^{88}Y}}{\sigma_{^{87}Y}}\Sigma_i(2J_i+1)$ for each multiplet of ^{88}Y states homologous to the ^{87}Y parent states we have identified are reported as a function of J_i, together with the straight $(2J+1)$ line. The satisfactory agreement between the experimental data and the prediction of the weak coupling model supports the spin and parity assignement of the ^{88}Y homologous levels.

We want to stress that the homology concept allows us to single out the dominant configuration of a given transition simply by comparison with experimental results of the parent nucleus, without applying complex shell model calculation.

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