"M1 TRANSITIONS FROM ISOBARIC ANALOG STATES IN (f-p) SHELL NUCLEI"[a]

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RESUMO

As intensidades das transições M1 para o decaimento dos estados análogos isobáricos, em núcleos com A = 49 até A = 57, tem sido calculadas no modelo de camadas no espaço extendido levando em conta excitações tipo partícula – buraco de caroço, inversão do spin do próton, bem como mecanismo de inverção do isospin do núcleon. Usa-se uma versão modificada da interação de Kuo – brown baseada na análise de regra de somas dos dados das reações de transferência de um próton na região (f–p). No espaço extendido do modelo, explica-se bem o 'Quenching' da intensidade de transição M1 para o decaimento de estado análogo isobárico, $3/2^-$ ao estado antianálogo de baixa energia nos núcleos ^{49}Sc, ^{51}V e ^{55}Co. Um aumento, quando comparado com valores de partícula única, das intensidades de transição M1, para o decaimento dos estados análogos – $1/2^-$ e $5/2^-$ é previsto. Os espectros de energia e as distribuições das intensidades de transferência de único próton são discutidas.

PALAVRAS-CHAVE: *Transições-M1; Fatores espectroscópicos; Modelo de Camadas; Estados Análogos Isobáricos; Região (f-P).*

1 – INTRODUCTION

High resolution single nucleon transfer data and (p,n) reaction data available for ^{49}Sc, ^{51}V, ^{53}Mn and $^{55,57}Co$ Nuclei show characteristic single nucleon transfer strength distributions. Many of the states, characterised by isospin value T >, are readily identified as analogs of the low-lying states in the neighbouring (target+one neutron) spectra. Another interesting feature is a strong quenching of the observed M1 transition strength for $3/2^-$, Analog state, decay to the strongest $3/2^-$, T < state, as compared to the weak-coupling model predictions. Maripuu [1,30] has earlier explained the quenching of M1 transition strength as being due to the mixing of single– particle state with core-polarised components. A recent study [2] of isovector magnetic transitions for N = 29 and N = 28 isotones shows that spin non-flip ($f_{7/2}$–$f_{7/2}$) transition plays an important role. The present shell-model study aims at a quantitative understanding of the observed quenching of M1 transitions besides trying to reproduce the multiplicities, relative energy-spacings and spectroscopic strength distributions for $3/2^-$, $5/2^-$ and $1/2^-$ states in the nuclei mentioned above.

Shell-model calculations have been carried out for N = 28 nuclei by Auerbach [3] taking proton configurations ($1f^n_{7/2}$) and ($1f^{n-1}_{7/2}$ * $2p_{3/2}$) outside a ^{48}Ca core. The mixed configuration calculations of Lips and McEllistrem [4] fail to predict $5/2^-$ and $1/2^-$ levels in ^{51}V and ^{53}Mn since no $1f_{5/2}$ and $2p_{1/2}$ protons are included in allowed configurations for these nuclei. Experimentally observed $3/2^-$ transfer strength distribution is also not reproduced for ^{51}V, ^{53}Mn and ^{55}Co nuclei. The predictions of strong coupling symmetric rotator model including coriolis coupling applied to some (f–p) shell nuclei by Malik and Scholz [5] have been found to be inconsistent with experimental observations. A dynamical model calculation [6] of odd–A (f–p) shell nuclei, however, gives a good description of low-lying spectra. An odd-nucleus in this model is described as a particle coupled to (A–1) nucleons or an odd-hole coupled to (A + 1) nucleons. For the case of ^{49}Sc, Bloom et. al. [7] calculated the $3/2^-$ and $1/2^-$ states using Kuo and brown interaction. Though the reduction of transition strength for $3/2^-$ analog state decay to the strongest T < level is reproduced, the interaction does not place the energy centroids of T > and T < states at right position hence the configuration mixing is not realistic.

A recent shell-model calculation [8] in a model

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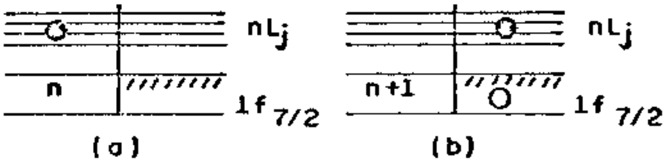
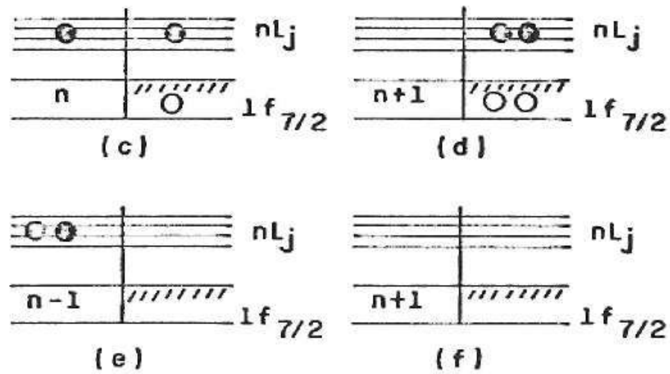
space including excitations of one nucleon from $1f_{7/2}$ orbit to $2p_{3/2}$, $1f_{5/2}$ and $2p_{1/2}$ orbits for nuclei with (A = 52 – 55) shows an improved agreement with experiment for properties of low-lying excited states. For M1 transitions spin-flip and isospin-flip modes of nucleon excitations are important. We use an extended model space which includes the relevant core excited configurations so as to account for (1p-1h) excitations of the core, $(2p_{3/2}-2p_{1/2})$ and $(1f_{7/2}-1f_{5/2})$ spin-flip as well as (n–p) isospin-flip mechanisms.

2 – BASIS VECTOR SPACE AND TWO-BODY INTERACTION

The calculations have been done within the frame work of shell-model in (n–p) formalism. Using standard multipole techniques [9], state operators are constructed for states arising due to relevant configurations for a given nucleus. The state operator for a given single-particle orbit has neutron operator coupled to proton part of the operator for the same orbit. Shell model code 'SHAMILT' was developd following the general scheme given by French et. al. [10] and can handle neutrons and protons in upto eight orbits.

We focus attention on the states arising due to single proton transfer to $2p_{3/2}$, $1f_{5/2}$ and $2p_{1/2}$ orbits of a target nucleus represented by pure shell-model configutarion of the type $[\ \nu\,(1f^{8}_{7/2}) \times \pi\,(1f^{n}_{7/2})\ ]\ J_0T_0$ outside a ^{40}Ca core; with $T_0 = \frac{N-Z}{2}$ and n = 0, 2, 4, 6. In addition the case of ^{56}Fe target, having two neutrons in $2p_{3/2}$ orbit is also considered. The interaction of the incoming proton with the target excites the core as such the residual nucleus states have contributions from configurations with particle coupled to various core excited states. The simplest of the core excitation modes is angular momentum excitation due to the readjustments of nucleonic orbits. Particle-core interaction may as well flip the spin of a $2p_{3/2}$ or $1f_{7/2}$ nucleon or flip the isospin of $1f_{7/2}$ neutron. In general, the incoming proton may be coupled to (1p–1h) excitations of the core. Our model space comprises the $(1f^{m}_{7/2})$, $[\ (1f^{m-1}_{7/2}) \times (2p_{3/2}, 1f_{5/2}, 2p_{1/2})^1\ ]$ and $[\ (1f^{m-2}_{7/2}) \times (2p_{3/2}, 1f_{5/2}\ 2p_{1/2})^2\ ]$ configurations, as shown in Fig. (1), and accounts for the core excitation processes mentioned above taking place in the (f–p) space. For ^{57}Co nucleus two additional neutrons are restricted to $2p_{3/2}$ orbit in seniority zero state.





The effective interaction is a modified Kuo-Brown [11] interaction with T = 0 part of $(1f_{7/2}-2p_{3/2})$, $(1f_{7/2}-2p_{1/2})$ and $(1f_{7/2}-1f_{5/2})$ interaction made more attractive by adding –0.5 MeV. On the other hand, T=1 part of $(1f_{7/2}-2p_{3/2})$ and $(1f_{7/2}-2p_{1/2})$ interaction is weakened by 0.2 MeV. Two-body matrix elements of

Table 1. Modified Kuo and Brown interaction matrix elements (in MeV)

$2j_r2j_s2j_t2j_u$	J = 0	J = 1	J = 2	J = 3	J = 4	J = 5	J = 6	J = 7
				$W^{JT=0}_{rstu}$				
7 7 7 7 [a]	0.0	–2.114	0.0	–1.044	0.0	–0.868	0.0	–2.278
5 7 5 7		–4.121	–3.231	–1.485	–2.386	–0.612	–2.716	
3 7 3 7			–0.798	–1.104	–0.664	–2.665		
1 7 1 7				–1.984	–1.246			
				$W^{JT=1}_{rstu}$				
7 7 7 7 [a]	–2.110	0.0	–1.110	0.0	–0.100	0.0	0.230	0.0
5 7 5 7		–0.013	0.204	0.278	0.331	0.456	–0.594	
3 7 3 7			–0.661	0.173	0.153	0.345		
1 7 1 7				0.229	–0.074		-	

a) Ref. [15]

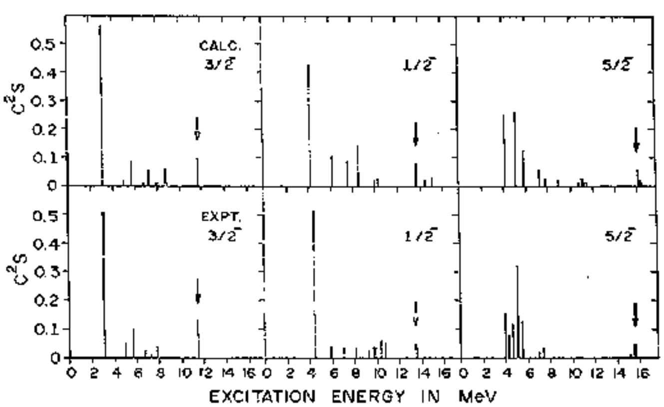
$(1f_{7/2}-1f_{5/2})$ part of interaction have been made more repulsive by 0.3 Mev. Such modifications are suggested by comparison of average Kuo-Brown interaction energies with empirical average interaction parameters obtained by sum rule analysis [12] of (f–p) shell single nucleon transfer reaction data. The pure KB interaction predicts highly compressed spectra [13] in the sense that correct energy splitting between the T > and T < sets of states is not reproduced. The modifications are aimed at producing realistic energy separations between $3/2^-$, $1/2^-$ and $5/2^-$ energy centroids and are consistent with those suggested by Pasquini and Zuker [14]. The single-particle energies used for $1f_{7/2}$, $2p_{3/2}$; $2p_{1/2}$ and $1f_{5/2}$ orbits are 0.0, 2.1, 4.4 and 6.6 MeV, respectively. Empirical values [15] have been used for $(1f^{2}_{7/2})$ two –body matrix elements. Table (1) lists the two-body matrix elements which have been modified.

3 - ENERGY - SPECTRA AND SPECTROSCOPIC STRNGTHS

Calculated and experimental spectroscopic factors

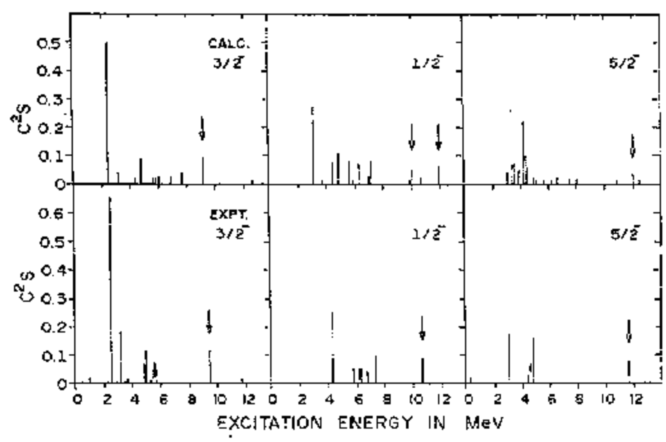
(C^2S) versus excitation energies are presented for $3/2^-$, $5/2^-$, $1/2^-$ levels in nuclei ^{49}Sc, ^{51}V, ^{53}Mn and $^{55,57}Co$ in Fig. (2–6). To facilite comparison calculated strongest $3/2^-$, T < level has been made to coincide with its experimental counterpart in all the cases. This amounts to an overall shift of 1.11, 0.24, 0.11, –0.53, and –0.65 MeV of the calculated spectra in the case of ^{49}Sc, ^{51}V, ^{53}Mn, ^{55}Co and ^{57}Co nuclei respectively. No parameter fitting has been done to produce absolute energies which are very sensitive to $(lf^2_{7/2})$ part of the interaction. We notice however that the correct relative energy splittings between strongest T > and T < states for each J^π value as well as those belonging to different J^π values are reproduced. This can be taken to indicate that the energies of the states being mixed have correct energy separations between themselves thus configuration mixing is more realistic.

SCANDIUM – 49



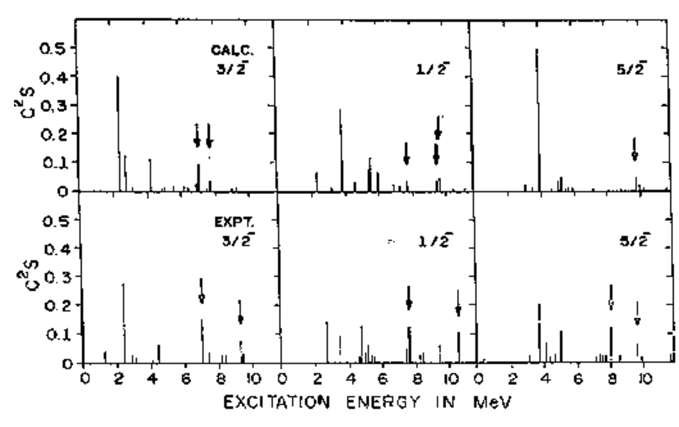
^{49}Sc: – We may note that for ^{49}Sc all the calculated levels upto 6.14 MeV are readily identified with their counterparts in experimental spectra [16][31] and calculated C^2S values are in good agreement with the measured ones. Fig. (2) shows the calculated strongest $3/2^-$, $5/2^-$ and $1/2^-$ levels at 3.08, 4.16, and 4.24 MeV respectively as compared to corresponding observed levels at 3.08, 4.07, and 4.49 MeV. Calculated strongest $3/2^-$, T > level at 11.75 Mev compares well with the observed $3/2^-$ analog state at 11.57 MeV. For calculated $1/2^-$ and $5/2^-$ analog states at 13.67 MeV (C^2S = 0.08) and 16.03 MeV (C^2S = 0.06) observed analog states lie at 13.557 MeV (C^2S = 0.04) and 15.584 MeV(C^2S = 0.05) respectively.

VANADIUM – 51



^{51}V: – In this nucleus, Fig. (3), the strongest $3/2^-$, T = 5/2 state at 2.41 Mev carries 50% of the spectroscopic strength whereas its experimental [17] counterpart is much stronger with 65% strength. A spin assignment of $5/2^-$ to the level at 3.07 MeV (C^2S = 0.17) is consistent with 14% strength seen split up into two components at 3.39 MeV and 3.50 MeV in the calculated $5/2^-$ spectra. The calculated Isobaric Analog States are readily identified with their experimental counterparts.

MANGANESE – 53



^{53}Mn: – With five protons outside a ^{48}Ca core, we expect ^{53}Mn spectra to be much more complex than the other nuclei included in this study. The calculated as well as observed [18, 32] spectra, Fig. (4), shows at least three strong components for spin values of $3/2^-$ and $1/2^-$ with energies and strengths in reasonable agreement. For $5/2^-$ spectra theory concentrates 50% of the strength at

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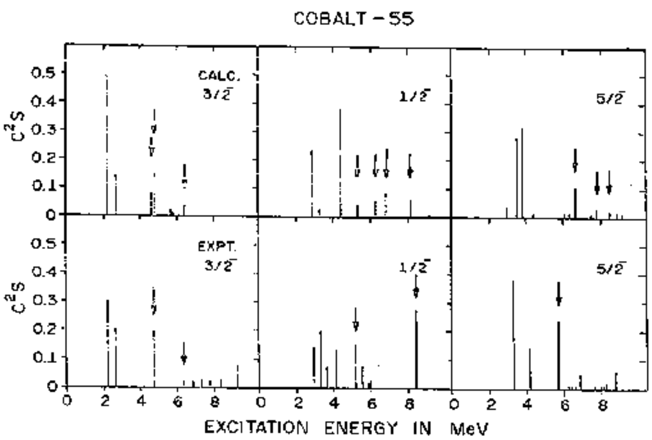
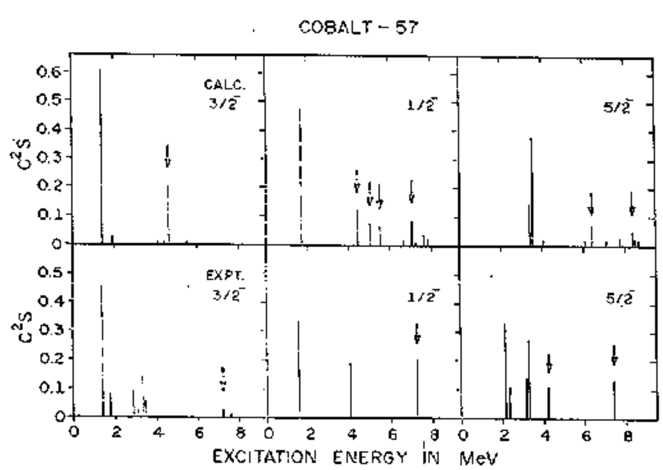
3.95 MeV, where as observed $5/2^-$ level with 21%, 7%, and 11% strength are seen at energies of 3.67 MeV, 4.07 MeV and 4.96 MeV respectively.

Experimentally various isobaric resonances with different spins and parities have been identified at excitation energies where resonances are well separated. A very good correspondence is obtained between calculated, T = 5/2, states, ($3/2^-$, 6.98 MeV), ($1/2^-$, 7.67 MeV) and the observed IAR at ($3/2^-$, 6.997 MeV), ($1/2^-$, 7.548 MeV) respectively.



^{55}Co: – The strongest calculated $3/2^-$ T < level carries a strength of 48%, whereas the measured [19] strength is about 30% though Ref. [20] reports an observed value of 42%. The observed $1/2^-$ level at 2.935 Mev is a possible candidate to be the counterpart of the calculated $1/2^-$ level carrying 24% strength. The strongest T < $1/2^-$ level is, nevertheless, found at 4.48 MeV in the calculated spectra. For proton transfer to $1f_{5/2}$ orbit, T < strength is seen to split up into two almost equally strong components at 3.51 MeV and 3.81 MeV in the calculated spectra. A similar splitting is clearly seen in the experimental spectra with the components placed at 3.30 MeV and 4.177 MeV respectively.



Theory reproduces reasonably well, Fig. (5), the relative energy splittings amongst the T > states for J^π = ($3/2^-$, $1/2^-$, $5/2^-$), as well as the spectroscopic strengths ^{57}Co: – Available ^{56}Fe (p, γ)^{57}Co and ^{56}Fe (^{3}He, d) ^{57}Co data [21,22] indicate that many characteristics of (f–p) shell nuclei are seen in ^{57}Co spectra. The calculated ^{57}Co spectrum is seen to be shrinked, Fig. (5), in the sense that the relative energy separation between the centroids of T > and T < sets of energy levels is smaller as compared to that observed experimentally. With two additional neutrons outside the ^{48}Ca core and the $1f_{7/2}$ orbit almost full for protons, ($1f_{7/2}-2p_{3/2}$) and ($2p_{3/2}-2p_{1/2}$) part of two-body interaction turns out to play a dominant role in ^{57}Co. The shrinkage of spectra as we go from ^{55}Co to ^{57}Co indicates that a suitable renormalisation of the interaction is necessary.

Calculated spectra show three levels, ($3/2^-$, 1.38 MeV), ($1/2^-$, 1.507 MeV), ($3/2^-$, 1.88 MeV) in good correspondence with those observed at ($3/2^-$, 1.377 MeV), ($1/2^-$, 1.507 MeV) and ($3/2^-$, 1.88 MeV).

4 – M1 TRANSITION STRENGTHS

Reduced M1 transition strengths for J^π, T > state decay to low-lying T < states are listed in W.u. in Tabels (2, 3 and 4).

In the model space used, a strong hindrance of M1 transition rate for $3/2^-$, analog state decay to strongest $3/2^-$, T < levels is well reproduced in nuclei ^{49}Sc, ^{51}V and ^{57}Co (Table 2, 3). Dominant M1 transitions for decay of $3/2^-$ analog states are shifted to a higher energy region as expected. It is interesting to note that isospin excitations as well as spin-flip reduce the transition strenght by a factor of 0.9×10^{-2} in ^{49}Sc. In ^{51}V nucleus, calculated total M1 transition strength of $0.54 \cdot 10^{-2}$W.u., for the decay of ($3/2^-$, T >) levels at 9.01 and 9.06 MeV to ($3/2^-$, T <) level at 2.41 MeV, is seen to be quenched by a factor 0.6×10^{-2} and matches well with the observed B(M1) value of 0.85×10^{-2} W.u. for 9.41 MeV analog state decay to 2.41 MeV state.

In the nucleus ^{53}Mn, theory predicts a reduction of M1 transition strength for the decay of $3/2^-$ analog state at 6.98 MeV to ($3/2^-$, T>) level at 2.41 Me V by a factor of $1.8 \cdot 10^{-2}$ as compared to the corresponding single-particle value. Also strong transitions to $3/2^-$ levels in energy region upto 6.42 MeV are expected. Experimental data for the decay of $3/2^-$ analog state at 6.97 MeV is very limited. For the higher lying $3/2^-$, analog state at 9.28 MeV M1 decay strength to antianalog state at 2.41 MeV is seen to be quenched by a factor of 0.19 whereas calculated reduction factor for corresponding decay is 0.06.

Calculated B(M1) values for the decay of ($3/2^-$, T = 3/2) state at 4.75 MeV in ^{55}Co nucleus, to levels at 2.16 MeV and 2.65 MeV are quenched as compared to single-particle value, but are seen to be stronger than the corresponding values reported experimentally (Table 4). On the other hand, M1 and E2 transition strengths for the decay of a higher lying calculated $3/2^-$ analog state at 6.41 MeV compare reasonably well with those for the decay of observed analog state at 6.83 MeV. Observed quenching of ($3/2^-$, analog state) at 7.26 MeV to the ($3/2^-$, T <) level at 1.38 MeV is well reproduced in the Nucleus ^{57}Co. However the calculation predicts a stronger transition to the next $3/2^-$, T <level contrary to a weaker transition reported for decay to level at 1.76 MeV.

TABLE 2. M1 Transition strengths (in W.u.) for the decay of Isobaric Analog States in the nuclei ^{49}Sc and ^{51}V.

Calc.							Expt.						
E_x^i (MeV)	→	E_x^f (MeV)	$2J^i$	→	$2J^f$	B(M1) (W.u.)	E_x^i (MeV)	→	E_x^f (MeV)	$2J^i$	→	$2J^f$	B(M1) (W.u.)
^{49}Sc													
11.75[c]	→	3.08	3	→	3	0.7×10^{-2}	11.57[c]	→	3.08	3	→	3	0.1×10^{-2}[b]
11.75	→	5.09	3	→	3	0.15	11.57	→	6.50	3	→	3	0.24[b]
11.75	→	6.77	3	→	3	0.41	11.57	→	6.73	3	→	3	0.29[b]
11.75	→	7.33	3	→	3	0.97	11.57	→	6.98	3	→	3	0.36[b]
11.75	→	8.78	3	→	3	0.51							
13.67[c]	→	4.24	1	→	1	3.8×10^{-2}							
13.67	→	9.00	1	→	1	1.60							
16.03[c]	→	4.16	5	→	5	0.39×10^{-2}							
16.03	→	5.19	5	→	5	2.0×10^{-2}							
^{51}V													
						B(M1) (W.u.)							B(M1)[d] (W.u.)
9.01[c]	→	2.41	3	→	3	0.34×10^{-2}	9.41[c]	D	2.41	3	→	3	0.85×10^{-2}
9.06[c]	→	2.41	3	→	3	0.20×10^{-2}							
9.06	→	4.45	3	→	3	0.35	9.41	→	4.26	3	→	3	0.05
9.06	→	5.95	3	→	3	0.15	9.41	→	4.65	3	→	3	0.12
9.06	→	6.84	3	→	3	0.15	9.41	→	4.85	3	→	3	0.13
9.06	→	7.59	3	→	3	0.27	9.41	→	5.30	3	→	3	0.06

a) Ref. (22), b) Ref. (23), c) Isobaric Analog State d) Ref. (24), e) Ref. (17).

TABLE 3. M1 transition strengths (in W.u.) for the decay of Isobaric Analog States in the nucleus ^{53}Mn.

Calc.							Expt.						
E_x^i (MeV)	→	E_x^f (MeV)	$2J^i$	→	$2J^f$	B(M1) (W.u.)	E_x^i (MeV)	→	E_x^f (MeV)	$2J^i$	→	$2J^f$	B(M1) (W.u.)
^{53}Mn													
6.98[c]	→	2.41	3	→	3	2.1×10^{-2}							
6.98	→	2.74	3	→	3	0.34							
6.98	→	4.25	3	→	3	0.31							
6.98	→	6.16	3	→	3	0.49							
6.98	→	6.42	3	→	3	0.41							
7.67[c]	→	2.30	1	→	1	9.2×10^{-2}	7.55[c]	→	2.67	1	→	1	4.1×10^{-2}[f]
7.67	→	3.78	1	→	1	4.5×10^{-1}	7.55	→	3.48	1	→	1	4.0×10^{-2}[f]
9.22[c]	→	2.41	3	→	3	6.6×10^{-2}	9.28[c]	→	2.41	3	→	3	2.2×10^{-1}[g]
9.52[c]	→	3.78	1	→	1	1.3×10^{-2}							
9.52	→	6.89	1	→	1	0.07							

9.66[c]	→	3.78	1	→	1	0.2×10^{-2}						
9.66	→	6.89	1	→	1	0.18						
9.71[c]	→	3.95	5	→	5	0.05	9.66[c]	→	3.67	5	→ 5	0.38[g]
9.76[c]	→	3.95	5	→	5	0.03						

c) Isobaric Analog State, f) Ref. (25), g) Ref. (26)

TABLE 4. M1 transition strengths (in W.u.) for the decay of Isobaric Analog States in the nuclei ^{55}Co and ^{57}Co.

Calc.							Expt.					
E_x^i (MeV)	→	E_x^f (MeV)	$2J^i$	→	$2J^f$	B(M1) (W.u.)	E_x^i (MeV)	→	E_x^f (MeV)	$2J^i$	→	$2J^f$ B(M1)[k] (W.u.)
^{55}Co												
4.61[c]	→	2.65	3	→	3	6.8×10^{-2}	4.71	→	2.56	3	→	3 3.6×10^{-3}[l]
4.75[c]	→	2.16	3	→	3	6.5×10^{-2}	4.75[c]	→	2.16	3	→	3 $<5.0\times10^{-3}$[l]
4.75	→	2.65	3	→	3	0.91	4.75	→	2.56	3	→	3 0.7×10^{-2}[l]
5.34[c]	→	2.89	1	→	1	1.30						
5.34	→	4.48	1	→	1	1.21						
6.41[c]	→	2.16	3	→	3	1.2×10^{-1}	6.83[c]	→	2.16	3	→	3 0.9×10^{-2}
6.41	→	2.65	3	→	3	1.9×10^{-2}	6.83	→	2.56	3	→	3 0.5×10^{-2}
6.41	→	4.75	3	→	3	1.0×10^{-1}	6.83	→	4.72	3	→	3 0.5×10^{-1}
^{57}Co												
						(B(M1) (W.u.)						(B(M1)m (W.u.)
4.67[c]	→	1.38	3	→	3	1.3×10^{-1}	7.26[c]	→	1.38	3	→	3 0.76×10^{-1}
4.67	→	1.88	3	→	3	2.8×10^{-1}	7.26	→	1.76	3	→	3 2.1×10^{-2}
4.43[c]	→	1 66	1									
4.43[c]	→	1.66	1	→	1	0.31						
5.04[c]	→	1.66	1	→	1	0.19						
6.44[c]	→	3.38	5	→	5	1.0×10^{-4}						
6.44	→	3.52	5	→	5	2.0×10^{-2}						

c) Isobaric analog State, k) Ref. (27), l) Ref. (28), m) Ref. (29), n) Ref. (21).

The mechanism responsible for the quenching of 3/2$^-$, analog state decay to antianalog state enhances the strength of M1 transitions, as compared to single particle values, for the (1/2$^-$, analog state) decay to low-lying (1/2$^-$, T <) levels as shown in Tables (2a, 2b and 2c). Also (5/2$^-$, analog state) M1 decay strengths, predicted to be entremely weak in weak coupling model, are an order of magnitude stronger for decay to 5/2$^-$, T < states lying in a higher energy region than the antianalog in nuclei ^{49}Sc, ^{51}V and Mn^{53}. In ^{53}Mn Isobaric analog resonance at 9.66 MeV is seen to decay to 5/2$^-$ – Antianalog state at 3.67 MeV with M1 transition strength enhanced by a factor of (47) as compared to the corresponding single-particle value. The calculated total M1–decay strength for 5/2$^-$, T > states at 9.71 MeV and 9.76 MeV to the strongest 5/2$^-$ level at 3.95 MeV is seen to be enhanced by a factor of (10) as compared to the single-particle value.

5 - CONCLUSIONS

Using a modified version of Kuo and Brown interaction, in a model space which accounts for isospin-flip, spin-flip and (1p-1h) excitations of core nucleons, the observed quenching of M1 transition strengths for ($3/2^-$, analog state) decay to the strongest ($3/2^-$, T <) level is well reproduced for the nuclei ^{49}Sc, ^{51}V and ^{57}Co. Quenching is partially due to configuration mixing and partially due to interference terms arising due to isospin-flip and spin-flip of the core nucleons. Similar reduction of B(M1) values is predicted by calculation for nuclei ^{53}Mn, and ^{55}Co. In all these cases, dominant M1 transitions are shifted to a higher energy region. As the target isospin varies from $T_0 = 4$ to $T_0 = 1$, the claculated quenching factor shows a slight increase and then diminishes as proton occupancy of $1f_{7/2}$ orbit increases.

An enhancement, compared to single particle values, of M1 transition strenghts for the decay of $1/2^-$, analog states and $5/2^-$, analog states to respective low-lying T < energy levels is predicted. Such behaviour is partially confirmed in the case of $5/2^-$, analog state decay in the nucleus ^{53}Mn.

ABSTRACT

M1 transition strengths for the decay of Isobaric Analog States in the nuclei with (A = 49 to A = 57) have been calculated in a shell model space which accounts for the (lp-lh) excitations of the core, proton spin-flip as well as isospin flip mechanisms. A modified version of Kuo and Brown interaction, based on sum-rule analysis of single nucleon transfer reaction data in the (f–p) region has been used. In the extended model space, the observed quenching of M1 transition strength for the 3/2⁻ Isobaric Analog State decay to the low lying antianalog state is well reproduced for the nuclei ^{49}Sc, ^{51}V and ^{55}Co. An enchancement, as compared to the single-particle values, of M1 transition strengths for the decay of 1/2⁻ and 5/2⁻ analog states is predicted. Energy spectra and single-proton transfer strength distributions are discussed.

KEY WORDS: *M1 transitions; Spectroscopic factors; Shell-model; Isobaric Analog States; (f–p) region.*

REFERÊNCIAS BIBLIOGRÁFICAS

1 – MARIPUU, S. *Nucl. Phys.* A153 (1970) 183.

2 – YOKOYAMA ATSUSHI & HORIE HISASHI. *Phys. Rev.* C38: 1058, 1988.

3 – AUERBACH, N. *Phys. Rev.* 163: 1203, 1967.

4 – LIPS, K. & MCELLISTREM, M.T. *Phys. Rev.* C 1: 1009, 1970.

5 – MALIK, F.B. & SCHOLZ, W. *Phys. Rev.* 153: 1971, 1967.

6 – LYSKOV, YU. A.; KAIPOV, D.K.; FISENKO, I.G. *Sov. J. Nucl. Phys.* *40*(3): 433, 1984.

7 – BLOOM, S.D.; MCGRORY, J.B.; MOSZKOWSKI, S.A. *Nucl. Phys.* A*199:* 369, 1973.

8 – HEES, A.G.M. VAN & GLAUDEMANS, P.W.M. *Z. Phys.*, 303: 267, 1981.

9 – FRENCH, J.B. *Proceedings of the international School of Physics, Enrico Fermi, Course* 36, editor C.B. Bloch, 278, 1966.

10 – FRENCH, J.B.; HALBERT, E.C.; MCGRORY.; J.B.; WONG, S.S.M. *Advances in Nuclear Physics,* BARANGER, 1969. v.3.

11 – KUO, T.T.S. & BROWN, G.E. *Nucl. Phys.* A*114:* 241, 1968.

12 – BANSAL, R.K., & SHELLY, S. *Phys. Rev.*, C *8:* 282, 1973.

13 – SHELLY S. Panjab University, Chandigarh, India, 1976. Ph.D Thesis.

14 – PASQUINI, E.A., & ZUKER, A. Proc. EPS Int. Conf. Nucl. Phys. Div. Florence, BLASI, P., RICCI, R.A.; (eds), 62, 1977.

15 – MCGRORY, J.B., & WILDENTHAL, B.H. *Phys. Letts.* B*103:* 173, 1981.

16 – FORTIER, S.; HOURANI, E., MAISON, J.M. *Nucl. Phys.* A*340: 285, 1980.*

17 – *Nucl. Data Sheets*, Vol *48;* 111, 1986.

18 – GUNN, G.D.; FOX, J.D.; KEKELIS, G.J. *Phys. Rev.*, C 13, 595, 1976.

19 – FORTIER, S.; MAISON, J.M.; LAURENT, H.; SCHAPIRA, J.P. *Nucl. Phys.* A*288:* 82, 1977.

20 – ARAI, E.; TAKETANI, T. *Nucl. Phys.* A*324:* 63, 1979.

21 – Nuclear Data Sheets, Vol. 48: 1, 1986.

22 – Nuclear Data Sheets, Vol. 48: 569, 1986.

23 – GAARDE, C.; KEMP. K.; PETRESCH, C.; FOLKMANN, F. *Nucl. Phys.* A*184:* 241, 1972.

24 – GAARDE, C.; KEMP, K.; NAUMOV, Y.U.; AMUNDSEN, P.R. *Nucl. Phys.* A*143:* 497, 1970.

25 – MARIPUU, S. *Nucl. Phys.* A*149:* 593, 1970.

26 – KEINWACHTER, P.; GERSCH, H.U.; SCHOBBERT, H. *Nucl. Phys.* A398: 476, 1983.

27 – Nuclear Data Sheets, Vol. 44: 463, 1985.

28 – SCHAPIRA, J.P.; MAISON, J.M.; RAO, M.N.; FORTIER, S.; GALES, S.; LAURENT, H. *Phys. Rev.*, C *17:* 1588, 1978.

29 – EL-KATEB, SALAH., & GRIFFITHS, G.M. *Nucl. Phys.* A*240:* 120 1975.

30 – MARIPUU, S. *Phys. Let.* B31, 181, 1970.

31 – KEMPER, K.W.; ZELLER; A.F., OPHEL, T.R. *Nucl. Phys.* A*348:* 339, 1980.

32 – GALES, S.; FORTIER, S.; LAURENT, H.; MAISON, J.M.; SCHAPIRA, J.P. *Phys. Rev.*, C 14: 842, 1976.

33 – ATOMS and NUCLEI. *Z. Phys. A*, 301: 189, 1981.

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