JOURNAL OF THE PHYSICAL SOCIETY OF JAPAN VOL. 34, SUPPLEMENT, 1973
PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON NUCLEAR MOMENTS AND NUCLEAR STRUCTURE, 1972

III-13 Effective M2 Gamma Transition Moments in Medium Nuclei

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The isovector component $\tau_3[\sigma\mathrm{xr}]_2$ of M2 gamma transition operator is the isobaric analogue to the unique first forbidden beta transition $\tau_\pm[\sigma\mathrm{xr}]_2$. The first forbidden β transitions with spin operator are uniformly reduced on account of the spin isospin core polarization.[1] It is very interesting to study M2 gamma matrix elements in order to see the similar effect of the spin isospin core polarization on the isovector component of the M2 operator. Comparison of the M2 γ matrix elements with the unique first forbidden β matrix elements may give information on the isoscalar component of the M2 operator.

We investigated the M2 gamma transitions from the $1h_{11/2}$ to the $1g_{7/2}$ single quasi proton states in ^{141}Pr, ^{143}Pm and ^{145}Pm. (note their neutron numbers $N \simeq 82$.) The $1h_{11/2}$ states were excited by the (α, $2n\gamma$) reactions. The bunched (2nsec wide every ~ 95 ns interval) alpha beam with $E = 20 \sim 24$ MeV was provided from the 110 cm Osaka Univ. cyclotron. The measured time spectra of the M2 transitions from the $1h_{11/2}$ to $1g_{7/2}$ states are shown in Fig. 1. The M2 gamma matrix elements are listed in Table* I. Here the conversion coefficients and the crossover $E3$ transitions from the $1h_{11/2}$ to $2d_{5/2}$ states have been corrected for. The last column of the table gives the effective M2 coupling constants, which are defined by

Table I.

	$T_{1/2}$ (ns)*	$B(\mathrm{M2})\left(\frac{e\hbar}{2MC}\right)^2(\mathrm{fm})^2$	$\frac{g_\gamma^{\mathrm{eff}}\mathrm{M2}}{g_{\mathrm{M2}}^{\mathrm{sp}}}$
^{139}Pr80	40±2	6.78±0.47	0.199
^{141}Pr82	4.7±0.3	11.1±0.8	0.242
^{143}Pm82	26.0±1.2	10.3±0.7	0.235
^{147}Eu84	740	5.40	0.186

* The preliminary $T_{1/2}$ of ^{143}Pm is in Phys. Letters. **38B** (1972) 73. Table I also include the $T_{1/2}$ for ^{139}Pr (D. B. Berry, *et al.* Phys. Rev. 188, 1851) and for ^{147}Eu (Nuclear Data *B2* No. 4)

$$g_\gamma\langle f\|\mathrm{M2}\|i\rangle_{\mathrm{exp}} = g_\gamma^{\mathrm{eff}}{}_0\langle f\|\mathrm{M2}\|i\rangle_0(U_iU_f + V_iV_f), \tag{1}$$

Here $|i>_0$ and $|f>_0$ are shell model wave functions, and the U, V factors used are those from the data of stripping and pick-up reactions.

The M2 matrix elements are uniformly reduced with a rate $g_\gamma^{\mathrm{eff}}/g_\gamma \simeq 0.2 \sim 0.24$, suggesting a distructive effect of the spin-isospin core polarization. A preliminary data on ^{145}Pm also indicates a similar value $g_\gamma^{\mathrm{eff}}/g_\gamma \simeq 0.3$. The values $g_\gamma^{\mathrm{eff}}/g_\gamma$ for the M2 transitions are of the same order as the rate $g_\beta^{\mathrm{eff}}/g_\beta \simeq$

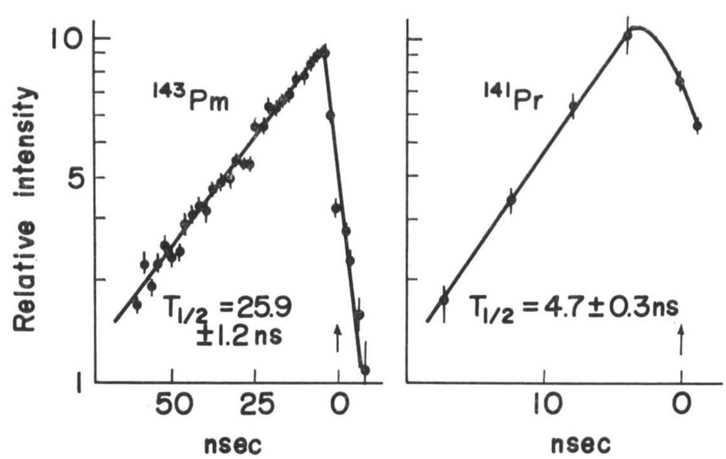

Fig. 1

0.2 for the unique first forbidden β transitions[2)] $(1h_{11/2}) \to (1g_{7/2})$. The M2 transition operator is effectively given by a sum of the isovector and isoscalar components,

$$\frac{g_\gamma^{\rm eff}}{g_\gamma} g_\gamma [\sigma \mathbf{x} \mathbf{r}]_2 = \left[\frac{g_1^{\rm eff}}{g_1} \frac{\tau_3}{2} \left(L\mu_- + \frac{L}{L+1} \right) + \frac{g_0^{\rm eff}}{g_0} \frac{1}{2} \left(L\mu_+ - \frac{L}{L+1} \right) \right] [\sigma \mathbf{x} \mathbf{r}]_2, \quad (2)$$

where $\mu_- = \mu_n - \mu_p$ and $\mu_+ = \mu_n + \mu_p$. The effective coupling constant $g_1^{\rm eff}$ for the isovector component $[\tau_3\, \sigma \mathbf{x} \mathbf{r}]$ can be obtained by choosing the spin isospin core polarization interaction $H_{\tau\sigma} = \chi \tau\tau\sigma\sigma \mathbf{r}\mathbf{r}$ so as to reproduce the effective coupling constant for the β transitions. We plot the eq. (2) in Fig. 2. The present M2 data, together with the β-decay data suggest some reductions of the isoscalar components of the M2 transitions provided μ_- is of the order of $\mu_n - \mu_p$ (solid line) $\sim 1.1.\ (\mu_n - \mu_p)$ (dotted line)

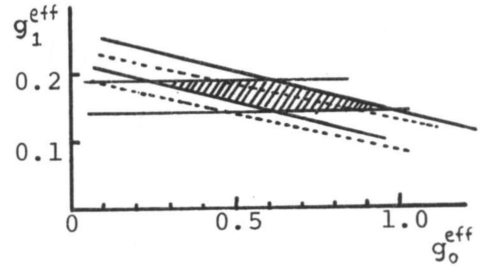

Fig. 2

References

1) H. Ejiri: Nuclear Phys. **A178** (1972) 350.
2) M. Morita and H. Ohtsubo: private communication.