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VI–12 Projected Hartree-Fock Calculations of Spin-Isospin Matrix Elements in $A = 17 - 27$ Nuclei

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Matrix elements $\langle\sum\sigma_z^{(i)}\rangle$, $\langle\sum\tau_3^{(i)}\sigma_z^{(i)}\rangle$, $\langle\sum l_z^{(i)}\rangle$ and $\langle\sum\tau_3^{(i)}l_z^{(i)}\rangle$ were obtained separately from measured magnetic moments and β-decay ft-values of mirror nuclei in $A \lesssim 40$ by K. Sugimoto *et al.*.[1,2] We calculate these matrix elements in the Projected Hartree-Fock approximation (PHF).

In the PHF method,[3] the wave function with definite angular momentum I and its z-component M is given by a following equation:

$$\Psi_{IM\alpha K}(\beta) = C_{I\alpha K}\int d\Omega \mathscr{D}^I_{MK}(\Omega)\psi_{\alpha K}(\beta, \Omega) \ , \qquad (1)$$

where Ω represents the Euler angles, $\mathscr{D}^I_{MK}(\Omega)$ is the usual representation of the rotation group and $C_{I\alpha K}$ is the normalization factor. The intrinsic wave function $\psi_{\alpha K}(\beta, \Omega)$ with the projected angular momentum K on the nuclear symmetry axis is given by a Slater determinant

$$\psi_{\alpha K}(\beta, \Omega) = |\alpha_1, \alpha_2, \cdots, \alpha_A; \beta\Omega> \ , \qquad (2)$$

where α_i's represent single-particle states in the intrinsic nuclear field characterized by the deformation parameter β and the Euler angle Ω. The magnetic moment μ is given as the expectation value of the magnetic dipole moment operator μ_z. Using eq. (1), we obtain

$$\begin{aligned}\langle\Psi_{II\alpha K}(\beta)|\mu_z|\Psi_{II\alpha K}(\beta)\rangle &= 32\pi^4 C^2_{I\alpha K}(2I+1)^{-1}\langle II10|II\rangle \\ &\times \sum_{\kappa',\mu}\langle I\mu 1\kappa'|IK\rangle\int_0^\pi d\theta \sin\theta \, d^I_{\mu K}(\theta) \\ &\times \langle\psi_{\alpha K}(\beta, 0)|\hat{\mu}_z|\psi_{\alpha K}(\beta, \theta)\rangle \ . \qquad (3)\end{aligned}$$

In the numerical calculation, we use the energy level splittings in the spherical field ($\beta = 0$) shown in the Table I. The β-dependences of these matrix elements are illustrated in Figs. 1 and 2. The deformation parameter β at which the calculated $\langle\sum\tau\sigma\rangle$ value is closer to measured one is adoped to calculate the values given in Table II. By using such β's, the fairly good agreements between measured and calculated energy spectra are obtained.

The numerical results indicate the systematical differences between measured and calculated values; Calculated $\langle\sum\tau l\rangle$ values are larger than measured ones by about 0.1, while calculated $\langle\sum\tau\sigma\rangle$ values are smaller by 20% at most. For $\langle\sum\tau\sigma\rangle$ matrix elements,

Table I. Used energy level splittings between spherical single-particle states $s_{1/2}$, $d_{3/2}$ and $d_{5/2}$. (in MeV)

	$s_{1/2}$	$d_{3/2}$	$d_{5/2}$
$A = 17 - 21$	-3.27	0.94	-4.14
$A = 23 - 27$	-2.78	0.94	-5.26

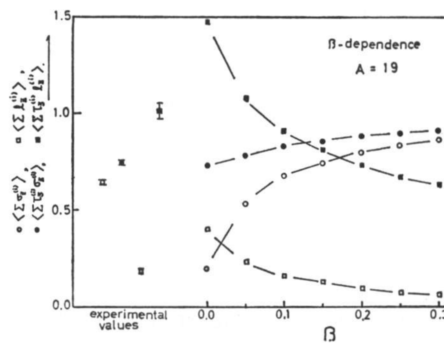

Fig. 1

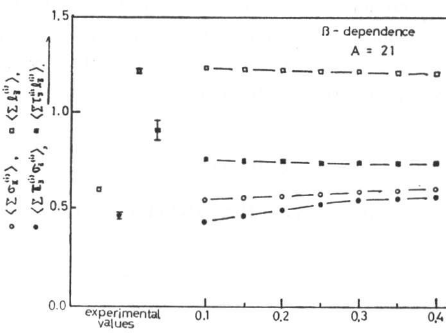

Fig. 2

Table II. The measured and calculated valued of matrix elements $\langle\sum\sigma\rangle$, $\langle\sum\tau\sigma\rangle$, $\langle\sum l\rangle$ and $\langle\sum\tau l\rangle$.

		Experimental values*)	Pure j–j coupling shell model	Projected Hartree-Fock Cal.	β
$A=17$	$\langle\sigma\rangle$	0. 865(4)	1. 0	1. 0	
	$\langle\tau\sigma\rangle$	0. 867(9)	1. 0	1. 0	
$5/2^+$	$\langle l\rangle$	2. 067(2)	2. 0	2. 0	
	$\langle\tau l\rangle$	2. 54(4)	2. 0	2. 0	
$A=19$	$\langle\sigma\rangle$	0. 637(3)	0. 2	0. 675	
	$\langle\tau\sigma\rangle$	0. 745(8)	0. 733	0. 825	0. 10
$1/2^+$	$\langle l\rangle$	0. 181(2)	0. 4	0. 164	
	$\langle\tau l\rangle$	1. 01(4)	1. 467	0. 913	
$A=21$	$\langle\sigma\rangle$	0. 591(1)	0. 6	0. 550	
	$\langle\tau\sigma\rangle$	0. 457(11)	0. 666	0. 463	0. 15
$3/2^+$	$\langle l\rangle$	1. 205(1)	1. 2	1. 224	
	$\langle\tau l\rangle$	0. 90(5)	1. 333	0. 737	
$A=23$	$\langle\sigma\rangle$		0. 6	0. 581	
	$\langle\tau\sigma\rangle$	0. 332(7)		0. 459	0. 20
$3/2^+$	$\langle l\rangle$		1. 2	1. 209	
	$\langle\tau l\rangle$			0. 701	
$A=25$	$\langle\sigma\rangle$		1. 0	0. 878	
	$\langle\tau\sigma\rangle$	0. 548(6)	0. 619	0. 720	0. 20
$5/2^+$	$\langle l\rangle$		2. 0	2. 061	
	$\langle\tau l\rangle$		1. 238	1. 412	
$A=27$	$\langle\sigma\rangle$		1. 0	0. 888	
	$\langle\tau\sigma\rangle$	0. 469(6)	1. 0	0. 812	0. 30
$5/2^+$	$\langle l\rangle$		2. 0	2. 056	
	$\langle\tau l\rangle$		2. 0	1. 805	

*) The listed values are taken from ref. 2.

a part of the deviation of calculated values from experimental ones is attributed to the renormalization of the magnetic dipole operator and the mesonic exchange effect. The large deviations of $\langle\sum\tau\sigma\rangle$ in $A=23-27$ nuclei can be caused partly by the softness against the γ-deformation.

References

1) K. Sugimoto: Phys. Rev. **182** (1969) 1051.
2) K. Sugimoto *et al.*: "Mirror Moments and Effective g-factors for Nucleons in Nuclei," presented at this conference III–1.
3) T. Une: "Deformation and Collective Motions in Light Nuclei (I)," OU-LNS.