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VI–16 Effect of Exchange Currents on Orbital g-Factors

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Recently a simple relation was derived between the change of orbital g-factors due to exchange currents and the sum rule for E1 photoabsorption on the basis of the assumption that the momenta of nucleons inside a nucleus have the Fermi-type distribution;[1]

$$2(\delta g_l^{\mathrm{P}})_{\mathrm{exch.}} = \kappa(\approx 0.4) \quad \text{for} \quad N \approx Z \,,$$

in which κ is defined by

$$\int \sigma_\gamma(\mathrm{E1})\mathrm{d}w = (\pi^2 \alpha A/2M)(1+\kappa) \,.$$

The purpose of this note is to reexamine the validity of the above relation on the basis of the shell model. In Table I the results of the zeroth-order shell calculations are shown for

$$\hbar\omega = 41\ A^{-1/3}\ \mathrm{MeV} \,.$$

From this Table we can draw several conclusions that a) the relation $\kappa/|\delta g_l| \doteqdot 2$ is roughly valid; b) the one-pion exchange potential (OPEP) explains only half of the $\kappa_{\mathrm{exp}} \approx 0.4$; c) for heavy nuclei, the isoscalar part of δg_l is important.

The point b) arises from the fact that the central space-exchange part of the OPEP is weaker by a factor of 2 than those of phenomenological nuclear potentials which can explain the fact that $\kappa \approx 0.4$. However, it should be noticed that the tensor part of the OPEP is partly changed into the central potential as the second-order effects;

$$V_{\mathrm{central}}^{\mathrm{eff.}} \approx -(\tau\tau)^2 \frac{\langle V_T^2 \rangle}{\Delta\varepsilon} P_{\mathrm{triplet.}}$$

It is already known[2] that the effective value of the energy denominator is about 240 MeV. In order to study this effect, we carried out the first-order perturbation calculations for the configuration mixing with 2 $\hbar\omega$ jumps. The results are shown in Table II. Actually the effect of configuration mixing due to

Table I. (For Rosenfeld mixture, we use $V = -28$ MeV and $r_0 = 1.414$ fm)

Nuclear Forces / Nuclei			OPEP δg_l	OPEP κ	Rosenfeld δg_l	Rosenfeld κ
^{15}N	$p_{1/2}^{-1}$	(p)	0.116	0.196	0.232	0.393
^{17}O	$d_{5/2}$	(n)	−0.064	0.199	−0.129	0.399
^{39}K	$d_{3/2}^{-1}$	(p)	0.108	0.196	0.217	0.395
^{41}Ca	$f_{7/2}$	(n)	−0.069	0.199	−0.139	0.399
^{87}Sr	$g_{9/2}^{-1}$	(n)	−0.068	0.187	−0.137	0.375
^{89}Y	$p_{1/2}$	(p)	0.160	0.187	0.320	0.376
^{89}Y	$g_{9/2}$	(p)	0.083		0.166	
^{91}Zr	$d_{5/2}$	(n)	−0.087	0.188	−0.175	0.377
^{207}Pb	$p_{1/2}^{-1}$	(n)	−0.122	0.183	−0.244	0.367
^{209}Bi	$h_{9/2}$	(p)	0.099	0.183	0.199	0.367

Table II.

Nucleus	$\Delta(\delta g_l)$	$\Delta\kappa$
^{15}N	−0.0016	0.011
^{17}O	−0.00022	0.011

tensor forces is seen to be small in so far as the lower levels are concerned.

Finally it should be remarked that, in order to compare our results with experiments, we must substract the second-order effects (mainly normalization effects) $(\delta g_l)'$ from the above $(\delta g_l)_{\mathrm{exch.}}$.

References

1) J. I. Fujita and M. Hirata: Phys. Letters **37B** (1971) 237; J. I. Fujita, S. Yamaji and M. Hirata: J. Phys. Soc. Japan **33** (1972) 541.
2) G. E. Brown: *Unified Theory of Nuclear Models,* second edition, (North-Holland, Amsterdam).