ELECTRIC AND MAGNETIC TRANSITIONS AND MOMENTS IN NUCLEI TWO NUCLEONS AWAY FROM ^{208}Pb

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In the theory of Fermi systems |1| the expectation values (or transition elements) of one-particle operators between states of an even-odd nucleus are related to those of the ground state in the neighbouring even-even nucleus by the so-called vertex function

$$\tau_{12}[Q] \equiv \langle\phi_{\nu_1}(A\pm1)|Q|\phi_{\nu_2}(A\pm1)\rangle - \langle\phi_o(A)|Q|\phi_o(A)\rangle, \quad (1)$$

which satisfies the equation:

$$\tau_{12}[Q] = \tau^{\omega}_{12}[Q] + \sum_{34} F^{ph}_{1423} \frac{n_3-n_4}{\varepsilon_3-\varepsilon_4-(\varepsilon_1-\varepsilon_2)} \tau_{34}[Q] \quad (2)$$

These equations are valid only if the even-even nucleus is of double magic type, and the states of the even-odd nucleus can be interpreted approximately as one-particle states. F^{ph} is the renormalized particle-hole interaction |1|, the n_i are equal to unity for states below the Fermi surface and zero above, and the ε_i are the exact energies of the even-odd nucleus. $\tilde{Q} \equiv \tau^{\omega}[Q]$, the renormalized operator, is in many cases connected with the bare operator Q by simple conservation relations. Numerical calculations have been carried out by the authors and collaborators |2|.

In order to get moments and transitions in (A$\pm$2)-particle nuclei one has to look for an equation of the extended vertex function:

$$\tau^{\alpha\beta}[Q] \equiv \langle\phi_\alpha(A\pm2)|Q|\phi_\beta(A\pm2)\rangle - \langle\phi_o(A)|Q|\phi_o(A)\rangle \quad (3)$$

This equation should of course take account of the interaction of the two additional particles (or holes). It turns out that, neglecting higher order correlation functions, only the inhomogeneous term of this equation is altered in comparison with eq. (2), whereas the homogeneous term, which describes the core polarization, remains the same. Defining a quasi-particle density matrix by

$$\tau^{\alpha\beta}[\Omega] = \sum_{12} \delta\rho_{21} \tilde{\Omega}_{12} , \qquad (4)$$

where $\tilde{\Omega}_{12}$ is equal to $\tau^{\omega}_{12}[\Omega]$ of eq. (2), one gets for the (A+2)-particle system ($\delta\rho$ being coupled to the angular momentum L carried by the operator Ω),

$$\delta\rho^{\alpha\beta,L}_{21,L} = 2(-1)^{j_1+j_2+L} \sqrt{(2J_\alpha+1)(2J_\beta+1)}$$

$$\sum_3 \left[(1-2n_1) \chi^{J_\alpha^*}_{13} \chi^{J_\beta}_{32} - \frac{n_1(1-n_3)+(1-n_1)n_3}{\varepsilon_1-\varepsilon_2-(\Omega_{J_\alpha}-\Omega_{J_\beta})} \Delta^{J_\alpha^*}_{13} \chi^{J_\beta}_{32} \right.$$

$$\left. + \frac{(1-n_3)n_2+n_3(1-n_2)}{\varepsilon_1-\varepsilon_2-(\Omega_{J_\alpha}-\Omega_{J_\beta})} \chi^{J_\alpha^*}_{13} \Delta^{J_\beta}_{32} \right] \begin{Bmatrix} J_\alpha & J_\beta & L \\ j_2 & j_1 & j_3 \end{Bmatrix} \qquad (5)$$

$$+ \frac{n_1-n_2}{\varepsilon_1-\varepsilon_2-(\Omega_{J_\alpha}-\Omega_{J_\beta})} \sum_{34} K^{ph}_{2314} \delta\rho^{\alpha\beta,L}_{43,L}$$

Ω_{J_α}, Ω_{J_β} are the exact energies of the states labelled by α and β, whereas the Δ's are defined by

$$\Delta^J_{12} = \frac{1}{2} \sum_{34} K^{pp}_{1234} \chi^J_{34} , \qquad (6)$$

where K^{pp} is an effective particle-particle interaction. The amplitudes χ^J_{ik} were either obtained by RPA-calculations with the same K^{pp} as in eq. (6) or were taken from the literature |3|.

The formula for the (A-2)-particle system differs from eq. (5) only by interchanging J_α and J_β.

Equation (5) shows two characteristic features:

(i) If a state of an (A+2)-particle nucleus can be described as a pure configuration of the type

$$(n_1 \ell_1 j_1,\ n_2 \ell_2 j_2,\ J_\alpha)\ ,$$

and the Λ's are negligible, then its (electric and magnetic) moments are the same as the values one gets by vector addition of the moments of the corresponding (A+1)-particle nuclei This additivity of effective moments is very satisfactorily confirmed by experimental results.

(ii) The homogeneous term shows a dependence on the energy difference between the initial and the final state. This dependence (which of course vanishes for moments) is negligible for many transitions. It becomes important however when the energy difference reaches the order of magnitude of an excited level of the corresponding A-particle nucleus.

TABLE 1

B-values of electric transitions in (A+2)-proton states (in units of e^2fm^4 and e^2fm^6).

Nucleus	Type of transition	$J^\pi \to J'^{\pi'}$	a	b	c	Exp.
^{210}Po	E2	$2^+ \to 0^+$	93.3	260.8	269.2	
	E2	$4^+ \to 2^+$	107.2	323.5	304.0	285±32
	E2	$6^+ \to 4^+$	74.15	223.5	208.7	247±33
	E2	$8^+ \to 6^+$	29.7	89.9	83.0	73±6
	E3	$11^- \to 8^+$	145.5	4918	2838	8500

a) Pure configuration without interaction

b) Kuo, Herling

c) RPA calculation with a density-dependent interaction

Some results of numerical calculations are given in tables 1 and 2. It should be emphasized that all para-

TABLE 2

Magnetic moments and a reduced M1-transition rate of (A+2)-neutron states.

Nucleus	J^π	a	b	c	Exp.
^{206}Pb	2^+	0.850	-0.057	0.071	-0.02±0.14
	7^-	-1.275	-0.301	-0.348	-0.15
	12^+	-3.532	-2.124	-2.124	-1.820±0.048
	$1^+ \to 0^+$	1.549	0.069	0.155	0.11

a) Schmidt value

b) Kuo, Herling

c) Tamm-Dancoff calculation with a density-dependent interaction

meters of K^{ph} have been taken from the results of calculations in neighbouring even-odd nuclei |2|.

REFERENCES

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