spectrum, i.e., the correction factor C is energy independent. Only the tensor interaction fails to give the required spectrum shape; it has been necessary to explain the spectrum shape by introducing the pseudoscalar interaction and assuming $g_P \gg g_T$ (Ref. 3).

The purpose of the present note is to focus attention on the fact that the spectrum shape of $0 \to 0$ (yes) transitions is in good agreement with the A covariant (the V covariant does not contribute due to selection rules), and to derive expressions for the electron polarization and electron-neutrino correlation. The required formulae may be obtained from the corresponding formulae valid for the T – P covariant,[4] provided one replaces q by $-q$ and $\lambda_P = -ig_P \int \gamma_5 / g_T \int \boldsymbol{\sigma}\cdot\mathbf{r}$ by $\lambda = -i\int \gamma_5 / \int \boldsymbol{\sigma}\cdot\mathbf{r}$, which now will be real:

$$C = \{(^1/_9 L_0 q^2 + M_0 - {}^2/_3 q N_0) + (2N_0 - {}^2/_3 L_0 q)\lambda + L_0\lambda^2\} \left| g_A \int \sigma r \right|^2, \quad (1)$$

$$\langle \sigma n \rangle = -C^{-1} \left| g_A \int \sigma r \right|^2 \{^1/_9 q^2 \sqrt{L_0^2 - P_0^2} + \sqrt{M_0^2 - Q_0^2} + {}^1/_3 q (\sqrt{(L_0+P_0)(M_0+Q_0)} + \sqrt{(L_0-P_0)(M_0-Q_0)}) - (\sqrt{(L_0+P_0)(M_0+Q_0)} + \sqrt{(L_0-P_0)(M_0-Q_0)} + {}^2/_3 q \sqrt{L_0^2 - P_0^2})\lambda + \sqrt{L_0^2 - P_0^2}\lambda^2\} \sin(\delta_{-1} - \delta_1), \quad (2)$$

$$W_{e\nu}(\theta) = 1 + \langle \sigma n \rangle \cos\theta.$$

The term $L_0 q^2/9 + M_0$ in the correction factor C increases with increasing energy, whereas $-2qN_0/3$ decreases, so that, to an accuracy of 5%, the expression $^1/_9 L_0 q^2 + M_0 - {}^2/_3 qN_0$ is constant. The expression $2N_0 - {}^2/_3 L_0 q$ is constant to within 2%. In the case of the T – P covariant the analogous quantities varied by a factor of 2 and by 40% respectively (for Pr^{144}). If we assume that the deviation from a Fermi shape does not exceed 5% then λ must satisfy $\lambda > 24$ or $\lambda < 3$ (the sign of λ is unknown). Under these conditions the electron polarization is practically indistinguishable from $-v/c$.

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[1] R. P. Feynman and M. Gell-Mann, Phys. Rev. **109**, 193 (1958).

[2] R. E. Marshak and E. C. G. Sudarshan, Phys. Rev. **109**, 1860 (1958).

[3] L. N. Zyrianova, Izv. Akad. Nauk SSSR, Ser. Fiz. **20**, 1399 (1956), (Columbia Tech. Transl. p. 1280).

[4] B. V. Geshkenbein, J. Exptl. Theoret. Phys. **33**, 1535 (1957), Soviet Phys. JETP **6**, 1187 (1958).

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CROSS SECTIONS FOR THE INELASTIC SCATTERING OF 4.5-Mev DEUTERONS BY CERTAIN LIGHT NUCLEI

E. A. ROMANOVSKII and G. F. TIMUSHEV

Moscow State University

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INELASTIC scattering of deuterons by atomic nuclei was studied essentially at two energy values: $E_d \sim 15$ Mev (Refs. 1 and 2) and $E_d \sim 9$ Mev (Refs. 3 to 5). There was hardly any investigation of inelastic deuteron scattering at lower energies.

When this investigation was started, it was known that the differential cross section of the (d, d′) reaction on Mg^{24} ($\Delta E = 1.37$ Mev, $E_d = 4.5$ Mev) scattering angle ($\vartheta_{lab} = 70°$) was 4 mbn/sterad.[6] One could conclude from the work of Khromchenko[7] that in many nuclei there is little probability for the (d, d′) reaction at $E_d \sim 4$ to 5 Mev, with the exception of Li^7. In the latter case the group of deuterons from the $Li^7(d, d')Li^{7*}$ reaction ($\Delta E = 0.476$ Mev), at $E_d \sim 3.7$ to 4.7 Mev and $\vartheta = 110°$, would be comparable in intensity with the group of deuterons elastically scattered from Li^7.

In this investigation we measured the differential cross sections for inelastic scattering of deuterons with $E_d \sim 4$ to 4.5 Mev from nuclei of Li^7, F^{19}, Na^{23}, Mg^{24}, and Al^{27}. A double-focusing magnetic analyzer[8] was used to sort the groups of inelastically-scattered deuterons. The deuterons were accelerated in the 72 cm cyclotron of the Institute of Nuclear Physics of the Moscow State University. To check the correctness of the identification of the deuteron group, the measurements were made at different energies E_d. The values obtained for the differential inelastic-scattering cross sections are given in the table for $E_d = 4.5$ Mev and $\vartheta_{lab} = 91°$.

The fourth and fifth columns of the table give the differential cross sections $d\sigma_{E_2}/d\Omega$ and the total cross sections σ_{E_2} for Coulomb excitation

nucleus	ΔE, Mev	$\frac{d\sigma}{d\Omega}$, mbn/sterad	$\frac{d\sigma_{E2}}{d\Omega}$, mbn/sterad	σ_{E2}, mbn	nucleus	ΔE, Mev	$\frac{d\sigma}{d\Omega}$, mbn/sterad	$\frac{d\sigma_{E2}}{d\Omega}$, mbn/sterad	σ_{E2}, mbn
Li^7	0.476	35			Na^{23}	0.439	9	0.15	2
F^{19}	0.197	16	0.06	0.7	Mg^{24}	1.370	7	0.20	3.5
F^{19}	1.355	2			Al^{27}	0.843	1.5		
F^{19}	1.426	2			Al^{27}	1.013	2.5		
F^{19}	1.558	8							

of the levels in F^{19}, Na^{23}, and Mg^{24}. The calculations were made with formulas (B-32) and (B-38) of Ref. 9. The probabilities given in the table for the transitions from the ground state into excited states with energies ΔE are taken from Refs. 9 and 10.

The tabulated results indicate that when E_d = 4.5 Mev the contribution of σ_{E_2} to the experimental value of σ_{tot} (σ_{tot} = 30 to 50 mbn for (d, d′) reactions on Mg^{24}, Na^{23}, and F^{19}) amounts to several percent. One can therefore conclude that at E_d = 4 to 4.5 Mev and above the process of nuclear excitation by the Coulomb field of the incident deuterons cannot be the dominant process that leads to inealstic scattering of the deuterons. This conclusion contradicts the (d, d′) reaction theory developed by Mullin and Guth.[11]

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[1] J. Haffner, Phys. Rev. **103**, 1398 (1956).
[2] Levine, Bender, and McGuer, Phys. Rev. **97**, 1249 (1956).
[3] R. Middleton, Proc. Phys. Soc. **A69**, 28 (1956).
[4] S. Hinds and R. Middleton, Proc. Phys. Soc. **A69**, 347 (1956).
[5] F. A. Bedewi, Proc. Phys. Soc. **A69**, 221 (1956).
[6] G. W. Greenless, Proc. Phys. Soc. **A68**, 97 (1955).
[7] L. M. Khromchenko, Izv. Akad. Nauk SSSR, Ser. Fiz. **19**, 277 (1956), (Columbia Tech. Transl. p. 252).
[8] G. F. Timushev, **Приборы и техника эксперимента** (Instr. and Meas. Engg.) (in press).
[9] Alder, Bohr, Huus, and Mottelson, Revs. Mod. Phys. **28**, 432 (1956).
[10] G. Rakavy, Nucl. Phys. **4**, 375 (1957).
[11] C. Mullin and E. Guth, Phys. Rev. **82**, 141 (1951).

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COMPTON SCATTERING OF CIRCULARLY POLARIZED PHOTONS BY ELECTRONS WITH ORIENTED SPIN

A. A. SOKOLOV and B. A. LYSOV

Moscow State University

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THE further development of the quantum electrodynamics of longitudinally polarized electrons and photons assumes new significance in connection with the discovery of parity nonconservation. As we have already noted,[1,2] to take longitudinal polarization of electrons into account one must, in the calculation of matrix elements, use not the Casimir formula but formula 2.12 of Ref. 3, in which s stands for the eigenvalue of the operator $(\Delta\sigma)/i\sqrt{-\nabla^2}$. This operator gives double the electron spin projection onto its direction of motion.

It is of interest to observe that the above-mentioned formula can also be used if the electron is initially at rest. In that case the formula may be brought into the form

$$\langle\alpha_{n'}, \alpha_n\rangle = \frac{1}{16}\mathrm{Sp}\,\alpha_{n'}\left(1 + \rho_1\varepsilon' s'\frac{k'}{K'} + \rho_3\varepsilon'\frac{k_0}{K'}\right) \times \left(1 + s'\frac{\sigma k'}{k'}\right)\alpha_n(1 + \rho_3\varepsilon)(1 + \sigma s), \quad (1)$$

where $\alpha_{n'}$, α_n are Dirac matrices characterizing the electron velocity, $\epsilon = \pm 1$ stands for the sign of the energy, the primed quantities refer to the final state of the electron, and the initial spin direction is chosen to be $\mathbf{s} = s\mathbf{k}/k$ ($\hbar\mathbf{k}$ is the elec-