In this case the temperature between the two neighboring adiabatic curves at a high pressure and a corresponding density (low specific volume v) is given by

$$T = \frac{E[p_1(v), v] - E[p_2(v), v]}{S_1 - S_2}$$

$$= T_0 \frac{E[p_1(v), v] - E[p_2(v), v]}{E[p_1(v_0), v_0] - E[p_2(v_0), v_0]}. \quad (4)$$

Consequently, if mechanical measurements giving $E(p, v)$ have been made, all the thermodynamic quantities can be determined along the adiabatic curves extended to where they join the region in which these quantities (T and S) can be determined by calculation or experimentally.

Let us carry out the formal operations substantiating this conclusion and leading to more convenient expressions for the temperature. Determining dS from (1), we then obtain

$$\frac{\partial^2 S}{\partial p \partial v} = \frac{\partial}{\partial v}\left(\frac{E_p}{T}\right) = \frac{\partial}{\partial p}\left(\frac{E_v + p}{T}\right) \quad (5)$$

Equation (5) is a partial differential equation for the absolute temperature; after elementary operations we obtain

$$(E_v + p)\,\partial T / \partial p - E_p \partial T / \partial v = T. \quad (6)$$

The characteristics of this equation are lines, whose differential equation is

$$dp / dv = -(E_v + p) / E_p \quad (7)$$

i.e., adiabatic lines [compare with Eq. (2)]. Along these lines Eq. (6) gives

$$dT / dv|_S = -T / E_p, \quad (8)$$

whence

$$T = T_0 \exp\left(-\int_{v_0}^{v} \frac{dv}{E_p}\right) = T_0 \exp\left(\int_{p_0}^{p} \frac{dp}{E_v + p}\right), \quad (9)$$

where the integrals are taken along the adiabatic line. Just as in Eq. (4), the temperature in Eq. (9) is everywhere proportional to the given value T_0 at the end of the adiabatic line.

In the present note we do not examine the question of the accuracy with which it is necessary to make the initial measurements of D and u, as well as of the velocities attained in adiabatic expansion, in order to be able to carry out the calculations for $E(p, v)$, the adiabatic lines, and finally the temperatures according to formulas (4) or (9).

In conclusion I wish to express my gratitude to L. V. Al'tshuler, S. M. Volosov, and N. A. Dmitriev for valuable discussions.

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Beta-Emission From Polarized Nuclei

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1. THE ANGULAR DISTRIBUTION of β-radiation from oriented nuclei has been investigated theoretically by Cox and De-Groot[1] and the writer.[2] However, it was assumed in these investigations that parity is conserved in β-decay. Recently it has been found that conservation of parity is violated in β-decay.[3,4] In view of this, the results obtained in the aforementioned investigations[1,2] are valid only for aligned nuclei, but are not valid for polarized nuclei.

In the general case the distribution of the β-particles in energy and in angle should be

$$W(E, \vartheta) = a_0 + a_1 f_1 P_1(\cos\vartheta) + \cdots + a_n f_n P_n(\cos\vartheta), \quad (1)$$

where $n \leq 2l + 1$ and $n \leq 2I$ (here I is the spin of the initial nucleus and l is the maximum orbital momentum carried off by the leptons), ϑ is the angle between the direction of the β-particle and the quantization axis, $a_0, \ldots, a_n$ are quantities dependent on the nuclear spin, on the type of β-transition and on the energy of the β-particle, and $f_1 \ldots, f_n$ are parameters characterizing the degree of orientation of the nuclei (see, for example, Ref. 5), normalized so that their maximum values will equal unity.

It is well known that β-interaction is a mixture of scalar and tensor forms of interaction. Lee and Yang[3] compute the angular distribution of β-radiation from polarized nuclei for allowed $\Delta I = \pm 1$ (no) β-transitions. Such transitions are due only to tensor interaction. It should also be of interest to examine allowed β-transitions of the $\Delta I = 0$ (no) type. By comparing the theoretical results for such transitions with the experimental data it should be possible to draw certain conclusions regarding the ratio of the β-interaction constants.

We note that all our calculations were carried out in the Born approximation.

2. We take the density of the matrix element for the β^--transition in the form

$$H = (\psi_p^+ \beta \psi_n)\,[C_S\,(\psi_e^+ \beta \psi_\nu) + C_S'\,(\psi_e^+ \beta \gamma_5 \psi_\nu)] + (\psi_p^+ \beta \boldsymbol{\sigma} \psi_n)\,[C_T\,(\psi_e^+ \beta \boldsymbol{\sigma} \psi_\nu) + C_T'\,(\psi_e^+ \beta \boldsymbol{\sigma} \gamma_5 \psi_\nu)] \tag{2}$$

(the notation here is that of Lee and Yang[3]). The relativistic term of the tensor interaction is not included here since it plays no part in these transitions.

Let us first examine allowed β-transitions with $\Delta I = 0 \pm 1$ (no). For the energy and angular distribution of the β-particles we obtain

$$\begin{aligned} W(E, \vartheta) = K \Big\{ &\Big|\int 1\Big|^2 (|C_S|^2 + |C_S'|^2) + \Big|\int \boldsymbol{\sigma}\Big|^2 (|C_T|^2 + |C_T'|^2) \\ &+ (2\mathbf{p}/E)\,[\mathbf{L}\,\mathrm{Re}\,(C_T C_T'^*) + \mathbf{Q}\,\mathrm{Re}\,(C_S C_T'^* + C_S' C_T^*) + \mathbf{R}\,\mathrm{Im}\,(C_S C_T'^* + C_S' C_T^*)]\Big\}, \end{aligned} \tag{3}$$

where

$$K = 4\pi (2\pi)^{-5}\, pEq^2,$$

Q, **L**, and **R** are the vectors introduced by Talhoek and De-Groot:[6]

$$\mathbf{L} = i\left[\left(\int \boldsymbol{\sigma}\right)\left(\int \boldsymbol{\sigma}\right)^*\right], \quad \mathbf{Q} = \frac{1}{2}\left\{\left(\int 1\right)\left(\int \boldsymbol{\sigma}\right)^* + \left(\int 1\right)^*\left(\int \boldsymbol{\sigma}\right)\right\},$$
$$\mathbf{R} = \frac{i}{2}\left\{\left(\int 1\right)\left(\int \boldsymbol{\sigma}\right)^* - \left(\int 1\right)^*\left(\int \boldsymbol{\sigma}\right)\right\}.$$

In the expression for **L** summation over the directions of spin of the final nucleus is implied. The other designations in formula (3) are standard. According to Talhoek and De-Groot[6] we obtain (after averaging over the nuclei)

$$\mathbf{L} = \Big|\int \boldsymbol{\sigma}\Big|^2 g f_1 \boldsymbol{\eta},$$

where η is a unit vector along the axis of quantization (z-axis) and the value of g is given by the expressions

$$g = 1/(I + 1);\ 1;\ -I/(I + 1),$$

respectively, for the $I \to I$, $I \to I - 1$ and $I \to I + 1$ transitions. Further, one can readily obtain

$$\mathbf{Q} = \sqrt{\Big|\int 1\Big|^2 \Big|\int \boldsymbol{\sigma}\Big|^2}\,\sqrt{I/(I+1)}\, f_1 \boldsymbol{\eta} \cos\alpha, \quad \mathbf{R} = \sqrt{\Big|\int 1\Big|^2 \Big|\int \boldsymbol{\sigma}\Big|^2}\,\sqrt{I/(I+1)}\, f_1 \boldsymbol{\eta} \sin\alpha,$$

wherein α is determined by the formula

$$\exp(2i\alpha) = \left(\int 1\right)^*\left(\int \sigma_z\right) \Big/ \left(\int 1\right)\left(\int \sigma_z\right)^*.$$

Finally we obtain

$$W(E,\vartheta)=K\left\{\left|\int 1\right|^2(|C_S|^2+|C_S'|^2)+\left|\int\sigma\right|^2(|C_T|^2+|C_T'|^2)+\frac{2p}{E}f_1\cos\vartheta\left[g\left|\int\sigma\right|^2\mathrm{Re}\,(C_TC_T'^*)\right.\right.$$
$$\left.\left.+\sqrt{I/I+1}\sqrt{\left|\int 1\right|^2\left|\int\sigma\right|^2}(\cos\alpha\,\mathrm{Re}\,(C_SC_T'^*+C_S'C_T^*)+\sin\alpha\,\mathrm{Im}\,(C_SC_T'^*+C_S'C_T^*)\right]\right\}. \tag{4}$$

At present the results of investigations of β-spectra and $\beta-\gamma$ angular correlation have made it possible to determine the numerical values of $|C_S|^2+|C_S'|^2$ and $|C_T|^2+|C_T'|^2$. By making measurements of the angular distribution in the case of a β-transition with $\Delta I=\pm 1$ (no) one can determine the value of $\mathrm{Re}(C_TC_T'^*)$ from comparison with theory. Further carrying out measurements of the angular distribution for a $\Delta I=0$ (no) type β-transition for which $\int 1$ and $\int\sigma$ can be computed, we can obtain through comparison with theory the numerical value of still another expression containing C_S, C_S', C_T and C_T'. Thus investigation of β-radiation from polarized nuclei makes it possible to draw certain conclusions regarding the β-interaction constants.

If we assume that there is conservation of combined parity[7] the results are simplified for in this case all the constants C are real. Comparison with experiment makes it possible to determine the numerical values of the quantities C_TC_T' and $C_SC_T'+C_S'C_T$. Knowing also $C_S^2+C_S'^2$ and $C_T^2+C_T'^2$, it should be possible to determine the coefficients C.

For the above method of comparing theory with experiment it is necessary to calculate the matrix elements $\int 1$ and $\int\sigma$. These calculations are simplest in the case of a β-transition between the corresponding states of neighboring mirror isobars.

3. Let us also examine β-transitions of the $\Delta I=\pm 2$ (yes) type. As a result of these calculations we obtain

$$W(E,\vartheta)=\frac{K}{4}\left\{(|C_T|^2+|C_T'|^2)\,T_{ik}\left(p_ip_k+\frac{q^2}{3}\delta_{ik}\right)\right.$$
$$\left.+2\mathrm{Re}\,(C_TC_T'^*)\,\frac{1}{E}\left(S_{ikt}\,p_ip_kp_t+\frac{q^2}{3}S_{iit}p_t\right)\right\}, \tag{5}$$

where

$$T_{ik}=B_{ni}B_{nk}^*,\quad S_{ikt}=i\varepsilon_{nmt}B_{ni}B_{mk}^*, \tag{6}$$

here B_{ik} is the known symmetric tensor with trace zero:

$$B_{ik}=\int\left(\sigma_ix_k+\sigma_kx_i-\frac{2}{3}\sigma_tx_t\delta_{ik}\right) \tag{7}$$

(everywhere in the above repeated indices imply summation, in (6) summation is implied over the direction of spin of the final nucleus).

Carrying out the calculation of the matrix elements, we finally obtain

$$W(E,\vartheta)=\frac{K}{12}T_{nn}\{(|C_T|^2+|C_T'|^2)[p^2+q^2-af_2p^2P_2(\cos\vartheta)]+$$
$$+\mathrm{Re}\,(C_TC_T'^*)\,\frac{6p}{5E}\left[bf_1\left(p^2+\frac{5}{3}q^2\right)P_1(\cos\vartheta)-cf_3p^2P_3(\cos\vartheta)\right]\} \tag{8}$$

here $a=b=c=1$ for $I\to I-2$ transitions while for $I\to I+2$ transitions

$$a=I(2I-1)/(I+1)(2I+3),\quad b=-I/(I+1),$$
$$c=-I(I-1)(2I-1)/(I+1)(I+2)(2I+3).$$

We note that for these transitions the role of Coulomb effects is negligible.

Transitions with $\Delta I=\pm 2$ (yes) give nothing new as compared with allowed transitions as regard determination of the interaction constants. Further data on the interaction constants can be obtained by investigating the shape of the β-spectra associated with $\Delta I=0,\pm 1$ (yes) transitions.[8] Investigation of these β-spectra should make it possible to determine the value of $\mathrm{Re}(C_SC_T^*+C_S'C_T'^*)$.

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Electronic Resonance in Current-Carrying Solutions

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AS IS KNOWN, electronic resonance is observed in ammonia solutions of alkali metals.[1,2] This effect is due to the fact that in ammonia solutions the atoms of the alkali metals dissociate into electrons and positive ions. The positive ions have a noble gas electron structure and are diamagnetic, while the electrons, having a magnetic moment, are responsible for the electron resonance effect.

It must be noted that solutions of alkali metals in liquid ammonia are colored, the coloring being explained by the presence of "free" electrons in the solution.[3]

It was shown by Gordon and Broude[4] that coloring is observed in an initially colorless solution of table salt in ammonia when a current is passed through the solution. The developing color is reminiscent of that characteristic of ammonia solutions of alkali metals. These investigators also noted the deflection of the colored streams in a magnetic field, which, according to these authors, is indicative of the electronic character of the conduction.

We felt that deflection of streamlines in a magnetic field is not in itself a convincing argument in favor of electron conduction. Hence we undertook a series of experiments on detection of electronic resonance in solutions of NaCl in ammonia on the assumption that in the case of electronic conduction, electronic resonance incident to the passage of current should be observed. Obviously, the electronic resonance line in this case should have a shape and spectroscopic splitting factor analogous to those of the line observed in solutions of Na in NH_3.

For observation of electronic resonance at a frequency of 9000 Mc the ampoule containing the ammonia solution of NaCl was placed in the rectangular cavity (H_{102} mode) of a sensitive radiospectrometer. The ampoule had two sealed-in platinum electrodes.

As usual the cavity was placed in a constant magnetic field, modulated by a field having a frequency of 50 cps. The intensity of the constant field was selected so as to satisfy the condition $g\mu H = h\nu$, where g is the radio-spectroscopic splitting factor for the solution, μ is the magnetic moment of the electron and ν is the frequency of the radiospectrometer generator. The investigation showed that under ordinary conditions no electronic resonance is observed when there is no current through the salt solution. When a current is passed through the solution an electronic resonance line appears at approximately the same place as the line associated with Na in liquid NH_3 (see Fig. 1). The intensity of the line depends on the strength of the current. When the current is switched off the intensity of the absorption line gradually decreases.

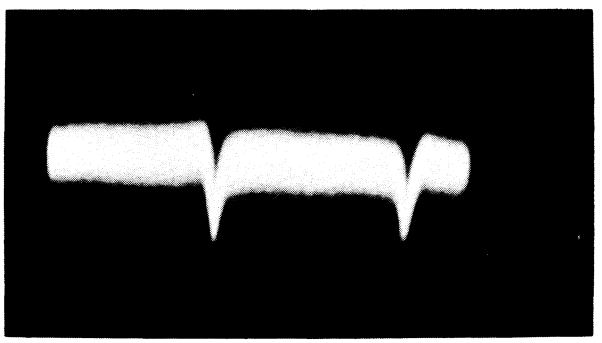

FIG. 1. Oscillogram of electronic resonance of a solution during passage of current.

Thus it is possible to observe electronic resonance only when electrons associated with the passage of current through the solution are present; this substantiates the electronic character of the conduction in these solutions.

If at the time of passage of current through the ampoule the solution is frozen in liquid nitrogen, the color of the solution is retained (there is no recombination of the electrons with the chlorine) and it is possible to observe electronic resonance even in the absence of a current (Fig. 2). In this manner