rates which are too high in comparison with the upper limits set by experiment. Taking account of the form factor with an accuracy including the first two terms in its expansion in powers of $(p/M)^2$ lowers the rate of, e.g., the $\Sigma^- \to p + e + \nu$ decay by a factor of 2.5 (reference 5). In the leptonic decays of the hyperons, therefore, either the unknown form factor plays an important role, or the decay mechanism is different from the four-fermion V-A interaction.

In the present note we consider the decay of a hyperon at rest into leptons via a virtual K meson whose spin is assumed to be zero (this should lead to a lower decay rate than that obtained with the local four-fermion interaction). We calculate the ratio, R, of the energy spectrum of the nucleons for the $Y \to n + \mu + \nu$ decay (a) and the corresponding spectrum for the $Y \to n + e + \nu$ decay (b). The experimental determination of R for the purpose of identifying the decay mechanism is, of course, much more difficult than the determination of the ratio of the decay rates. On the other hand, neither the absolute values of rates of the decays (a) and (b), nor their ratio can be computed exactly.

Without recourse to perturbation theory, we can write the matrix element for the decay process in the form

$$M = f(\varepsilon)(\bar{u}_n G \Gamma u_\nu)(\bar{u}_\mu \Gamma (g + g'\gamma_5) u_\nu) \qquad (1)$$

(the indices specifying the parity of the K meson are omitted), where Γ is either 1 or γ_5, and $f(\epsilon)$ is some unknown function of the nucleon energy, which also depends on .G and the masses M_Y, M_n, M_K, m_π, but not on either m_e or m_μ; G and g, g′ are the strong and weak coupling constants, where $gfG \to g_S$ (or g_P) for $M_K \to \infty$. These expressions for M correspond to the S and P variants of the theory of the four-fermion interaction. According to (1), we obtain for the energy dependent (i.e., the nucleon energy) decay rate

$$dW/d\varepsilon = \mathrm{const}\cdot|f|^2\sqrt{\varepsilon^2 - 1}$$
$$(\varepsilon_{max} - \varepsilon)^2(\varepsilon \pm 1)/(1 + M_Y^2 - 2M_Y\varepsilon), \qquad (2)$$

$\epsilon_{max} = (M_Y^2 - m^2 + 1)/2M_Y$ is the maximal energy of the nucleon in units of $M_n c^2$. The signs ± refer to a scalar and pseudoscalar virtual meson, respectively. It is seen from (2) that the ratio R is independent of the parity of the meson and of the factor f. It is connected with the analogous ratio F, obtained from the V-A variant without account of the energy form factor and the renormalization constant, in the following way:

$$F = R\left[m_\mu^2 + M_Y\left(1 - \frac{M_Y(\varepsilon^2 - 1)}{3(M_Y - \varepsilon)(M_Y\varepsilon - 1)}\right)\right]$$
$$\times\left[m_e^2 + M_Y\left(1 - \frac{M_Y(\varepsilon^2 - 1)}{3(M_Y - \varepsilon)(M_Y\varepsilon - 1)}\right)\right]^{-1} \equiv RH(\varepsilon), \qquad (3)$$

ϵ_{max}^{μ} and ϵ_{max}^{e} are the maximal energies of the leptons for the decays (a) and (b), respectively. We note that the factor $H(\epsilon)$, which determines the deviation of R from F near the upper limit of the energy spectrum of the nucleons, reaches the values ~2.5, ~2.0, and ~2.6 for the leptonic decays of the Λ^0, Σ^-, and Ξ^- hyperons, and is close to unity at the beginning of the spectrum.

In conclusion I thank I. S. Shapiro for suggesting the topic of the present note and for interest in this work.

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ASYMMETRY OF ANGULAR DISTRIBUTION OF $\mu^+ \to e^+$ DECAY ELECTRONS IN A 27,000 GAUSS MAGNETIC FIELD

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It is known that the angular distribution of $\mu \to e$ decay electrons is given by

$$4\pi dN/do = 1 - a\cos\theta, \quad a = \lambda P/3 = a_0 P, \qquad (1)$$

where $\lambda = 3a_0 = -\cos(V, A)$ determines the relative contribution of the vector and pseudovector interactions in the $\mu \to e$ decay; P is the μ-meson polarization. The maximum possible value of the coefficient a, namely ⅓, corresponds to $\cos(V, A) = -1$ (V-A interaction). The different values of a $(0 - 0.26)$ obtained with the aid of electronic apparatus are explained by the depolarizing action of the medium in which the μ meson is slowed down and then decays. Such a determination of the coefficient a has that shortcoming, that not all the $\mu \to e$ decay electrons are registered with equal efficiency. Experiments on the observation of $\pi \to \mu \to e$ decays in photoemulsion permits registration of electrons of any energy with equal efficiency. However, the photoemulsion is a strongly depolarizing medium. The value of the coefficient a for the NIKFI type R emulsion was found[1] to be $a = 0.092 \pm 0.018$, while the average value of a for the Ilford G-5 emulsion can, according to data of many investigations, be assumed to be[2] equal to 0.14.

Swanson[3] combined the results obtained by electronic means for various substances (including emulsion) with the results of the measurement of the asymmetry of $\mu \to e$ decay in emulsion and in propane, and found for graphite values reaching $a = 0.303 \pm 0.048$, i.e., reaching almost the maximum value.

The depolarizing action of the medium decreases in the observation of μ-meson decay in a magnetic field having the same direction as the μ-meson polarization. When observing $\mu \to e$ decay in a longitudinal magnetic field, the increase in the coefficient a due to this effect can be found from the following formula:[4]

$$a = a_0\left[1 - \frac{0.5}{1 + (\mu H/\Delta E)^2}\right], \qquad (2)$$

where a_0 is the value of a in the absence of depolarization and ΔE is the energy of the hyperfine splitting of the μ-mesic atom in the 1S state. It follows from Eq. (2) that in practice a becomes equal to a_0 at fields $H \geq 8000$ Gauss. Equation (2) is not sufficiently reliable, for it does not take into account the electron exchange between the μ-mesic atom and the medium after production of the μ meson. Experiments aimed at verifying Eq. (2) where performed by several workers[4-6] for fields up to 14,000 Gauss, and it was shown that qualitatively $a(H)$ behaves like Eq. (2) in the case of many substances used to slow down μ mesons, including photoemulsion.

In the present investigation we determined the value of the coefficient a in Eq. (1) by observing the $\pi \to \mu \to e$ decay in an emulsion placed in a magnetic field with $H = 27{,}000$ Gauss. In scanning we selected the $\pi \to \mu \to e$ decay events in which the μ meson was emitted at an angle $\theta_\mu = 0 - 30°$ or $\theta_\mu = 180 - 150°$ with the direction of the field. A total of 11,166 such $\pi \to \mu \to e$ decay events was observed.

Particular attention was paid in the scanning to elimination of systematic errors due to the unequal efficiency of registering different $\pi \to \mu \to e$ decay events. Only such $\pi \to \mu \to e$ decay events were considered, in which the end of the μ meson was not closer than $15\,\mu$ to the surface of the developed emulsion layer. In only 47 events (0.42% of all the $\mu \to e$ decay events) was no $\mu \to e$ decay electron observed.

We measured the angle of emission of the $\mu \to e$ decay electron relative to the direction of the magnetic field. The electron-emission angle was measured from the direction of the magnetic field if the μ meson traveled "along the field" $(\theta_\mu = 0 - 30°)$ and from the opposite direction when the travel was "against the field" $(\theta_\mu = 180 - 150°)$. The value of a was determined from the relation

$$a = 2(N_{back} - N_{forward})/(N_{back} + N_{forward}), \quad \delta a = 2/\sqrt{N}.$$

The corresponding values of the coefficient a were found to be

$$a_1 = 0.315 \pm 0.026 \text{ for the case } \theta_\mu = 0–30°;$$
$$a_2 = 0.295 \pm 0.027 \text{ for the case } \theta_\mu = 150–180°.$$

The total value of a, averaged over both direction of emission of the μ meson, was found to be $a_3 = 0.305 \pm 0.019$.

The value of a in Eq. (1) exceeds somewhat the values of a_1, a_2, or a_3, owing to the depolarization of the muons by precession of the muon spin about the direction of the field H. Obviously $a_{true} = a_3\sqrt{\cos\theta_\mu}$. For the selected $\pi \to \mu$ decay events we found $\cos\theta_\mu = 0.940$, hence $a_{true} = a_3/0.940 = 0.324 \pm 0.020$.

It follows from this value that $|\lambda| P = 0.972 \pm 0.06$, i.e., with accuracy to within the statistical error (6%), $|\lambda|$ reaches its maximum value, and consequently $P \approx 1$. A determination of the sign of λ, i.e., the choice between the V − A and V + A variants of interaction, is impossible because the direction of the μ-meson polarization is unknown. The value obtained for $|\lambda|$ agrees with the Feynman-Gell Mann theory[7] of universal (V-A) interaction.

A strong magnetic field eliminates the polarization completely. Equation (2), which gives $a = f(H)$, is quite inaccurate. Work continues on improving the obtained value of a and on

$P_\mu \xi = 0.97 \pm 0.06$

μ^+, $B = 2.7$ T

measuring a in photoemulsions placed in various magnetic fields.

An analogous result, $a \approx 1/3$ was obtained by Vaĭsenberg et al. and Lynch et al.[2,8] for emulsions placed in strong magnetic fields.

In conclusions, the authors express their gratitude to B. S. Neganov and B. V. Sokolov for aid in the irradiation of the photoemulsions, to D. M. Samoĭlovich for developing the emulsion, and also to V. M. Kutukova, A. M. Alpers, and G. V. Pleshivtseva for help with the work.

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BROADENING OF SPECTRAL LINES IN STRONGLY IONIZED PLASMA

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MEASUREMENTS of the width of spectral lines are often used to determine the density of charged particles in a plasma; at the same time, the investigation of line broadening in a plasma is by itself an interesting physical problem, since under plasma conditions the emitting atoms are subjected to extremely strong rapidly-changing inhomogeneous fields of the surrounding particles, fields which cannot be achieved by other means. Until recently, only the line widths were usually studied; considerably greater information can be obtained if the line widths are measured simultaneously with the line shifts.

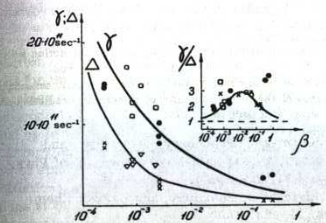
The results of our preliminary measurements of line widths and shifts in the plasma of a spark discharge[1] show a drastic qualitative disagreement with the existing Weisskopf-Lindholm theory, according to which the ratio of width to shift must have for all lines a constant value 1.6 and must depend on Stark's constant C_4 as $C_4^{2/3}$ (C_4 determines the line shift in a constant electric field, $\Delta\nu = F^2 C_4/e^2$, where e is the charge of the electron, $\Delta\nu$ is expressed in cm^{-1}, and F is in electrostatic cgs units). On the basis of these measurements, a new non-stationary theory of line broadening due to charged particles has been developed by Vaĭnshteĭn and Sobel'man,[2] according to which the broadening and shift substantially depend on the parameter $\beta = (Z\mu/m)(\Delta E/kT) \times (S/3ga_0^2)^{1/2}$. Here Z is the charge, μ is the mass of the perturbing particle, m is the mass of the electron, ΔE is the separation between the level under consideration E_1 and the nearest excited level E_2 (only one excited level is assumed to exist), and S is the oscillator strength of the line corresponding to the transition between the levels E_1 and E_2. The ratio of the width to the shift also depends on β and is not the same for all lines.

We have measured, with a considerably improved accuracy the widths and shifts of 50 lines of A II and several lines of He I in the plasma of the spark discharge in argon and helium (U = 14 kv, C = 0.02 μf, L = 10 μh) at temperatures of $3 \times 10^4 - 4 \times 10^4$ °K and an electron density of $\sim 10^{17}$ cm^{-3}. Spectra were photographed by means of a spectrograph with a dispersion of 2 A/mm. The line widths γ were measured in the usual manner, the line shifts Δ in the spectrum of the spark were measured relative to the same lines in the discharge spectrum of a hollow cathode, where the lines could be considered unshifted. The accuracy of the width measurements was 5 to 10%, the smallest definitely detectable shift was ≈ 0.03 A.

The results of measurements have confirmed the preliminary conclusions. In the accompanying table we give data for 6 lines of A II; they are typical for the rest of the lines measured. The constants C_4 are calculated from the measurements of Minnhagen[3] and Maissel[4] in a homogeneous field. The ratio γ/Δ varies from 2 to 10, and the width changes only by a factor of 3 or 4 when C_4 changes by two orders of magnitude.

λ, A	$10^{-11}\gamma$, sec^{-1}	$10^{-11}\Delta$, sec^{-1}	γ/Δ	$10^4 C_4$, $cm^4 \cdot sec^{-1}$	ΔE, cm^{-1}	β
4579.4	5.1	0.45	11.5	0.5	10000	0.31
4460.4	3.8	0.66	5.8	0.5	8000	0.22
4598.8	8.4	2.7	3.1	7.8	122	$2.6 \cdot 10^{-3}$
3561.0*	12	5.0	2.4	9.2	100	$2.2 \cdot 10^{-3}$
3559.5*	13	5.6	2.3	2.0	40.5	$8.5 \cdot 10^{-4}$
4474.8	15	7.8	1.9	5.5	13.5	$2.6 \cdot 10^{-4}$

*ΔE has been calculated for these lines.



Dependence of the width γ and the shift Δ on β. The curves give theoretical results; • and × are experimental γ and Δ for the lines with known ΔE; □ and ∇ are experimental γ and Δ for the lines with calculated ΔE. The insert gives the dependence of the ratio γ/Δ on β. The dashed line represents the results of the stationary theory; the solid curve represents the results of the non-stationary theory; • and □ are for the lines of A II; ○ are authors' measurements for the lines of He I; × are for the lines of He I after Wulff.[5]

The accompanying figure gives a comparison of experimental results with the results of the non-stationary theory. In our case the data necessary for the calculation of β (ΔE and S) are available for only 7 lines. For the remaining lines, in view of the incomplete term level diagram of A II, the values for ΔE are unknown. We have estimated these quantities by using the data on the shift in a homogeneous field,[4] assuming that the oscillator strengths are approximately the same for all lines. In the upper picture (dependence of γ/Δ on β) we have also plotted Wulff's[5] data for He I lines, for which we have calculated the β values (ΔE and S are known).

As can be seen from the figure, the agreement of the experiment with the non-stationary theory is quite good. It should, however, be noted that for several lines the experimental values $\gamma/\Delta \approx 10$ considerably exceed the theoretical values; in a number of cases this can be apparently explained by the existence of two or more excited levels.

By way of a practical conclusion it may be mentioned that it is advantageous to use line shifts for determining the electron density, since additional data on second-order collision cross sections are required for the calculations from the widths. Corresponding measurements for the plasma which we have investigated gave $n_e \approx 1.5 \times 10^{17}$ cm^{-3} for argon and $n_e \approx 7 \times 10^{16}$ cm^{-3} for helium in good agreement with the estimates obtained on the basis of line intensities of A II and A III with the aid of Saha's formula.

In concluding, we should like to remark that previously we used $\gamma/\Delta = 1.6$ for the lines of Ca I in the plasma of an arc.[6] For the investigated lines the non-stationary theory gives only minor corrections, and the conclusions of this investigation remain valid.

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