apparent agreement of the experimental values of A, reported earlier for many metals,[9] with the standard value of 120 amp. cm^{-2} $deg.^{-2}$ is more than fortuitous.

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Erratum: The Magnetic Threshold Curves of Superconductors

[Phys. Rev. **72**, 89 (1947)]
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August 24, 1948

In a letter with the above title a misprint occurred in Eq. (2), giving the temperature dependency of the number of superconductive electrons. This should read:

$$n_s = n_0[1-(T/T_c)^4].$$

This is in agreement with the experimental results obtained so far by penetration depth measurements.[1] It also can be deduced, as pointed out by the author earlier, from the two-fluid theory of superconductivity of Gorter and Casimir,[2] provided a parabolic form[3-5] is assumed for the magnetic threshold curves. A further discussion of this has been given by Miller.[6] It should be remembered that this result quoted above treats only the thermodynamic properties of the superconductor and any subsequent evaluation of electrodynamic properties must involve further assumptions.

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Divergence Difficulty and Mixed Meson Theory

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July 7, 1948

The divergence of the magnetic moment of the nucleon is one of the grave difficulties of Yukawa's theory of mesons. Another difficulty is that the nuclear potential involves also divergent integrals according to the one-meson theory, although this fact has not yet been fully noticed. These difficulties can be removed by mixing a pseudoscalar field with a pseudovector one. The pseudoscalar theory[1] gives the proton a positive surplus magnetic moment, whereas the pseudovector theory has a negative one. They are given by the following divergent integrals:

$$\mu_P = +(e/\hbar c)(f^2/\kappa^2)(2/3\pi)\int_0^\infty [k^4dk/(k^2+\kappa^2)^2] \quad \text{(pseudoscalar)}, \quad (1)$$

$$\mu_P = -(e/\hbar c)(g^2/K^2)(2/3\pi)\int_0^\infty [k^4dk/(k^2+K^2)^2] \quad \text{(pseudovector)}, \quad (2)$$

where f and g are, respectively, the constants of pseudovector and six-vector couplings of pseudoscalar and pseudovector mesons with nucleons, and $\hbar\kappa/c$ and $\hbar K/c$ are, respectively, the masses of pseudoscalar and pseudovector mesons. If we consider a mixture of both fields and, further, if we assume $(f/\kappa)^2=(g/K)^2$ and $\kappa<K$, the surplus magnetic moment of the proton becomes a following positive finite value:

$$\mu_P = (e/2\kappa)(f^2/\hbar c)[(K/\kappa)-1]. \quad (3)$$

This amounts to 1.86 nuclear magnetons, i.e., the observed value, if $K=4.7\kappa$, $f^2=0.05\hbar c$, and $M=10\mu$, where μ and M denote the masses of the pseudoscalar meson and the proton. Various experimental evidences are in favor of the pseudoscalar theory.[2] The scalar theory does not explain the magnetic moment of nucleons (in the Schrödinger approximation), and the vector theory gives the proton a positive surplus moment. Therefore, there is no remedy for the difficulty but the above-mentioned mixture. Schwinger's mixture[3] must be ruled out in this respect.

The present mixture removes also the divergent and r^{-3} difficulties from the nuclear potential. The nuclear potential in the symmetrical pseudoscalar meson theory has the same form as that given by (4) below, but ϕ and χ involve divergent integrals. The divergent part of ϕ represents a direct interaction and it can be eliminated in the relativistically invariant way by introducing its negative in the Hamiltonian.[2,4] In the case of the pseudovector theory the sign of (4) is to be reversed and f and κ are to be replaced by g and K. In this case ϕ and χ involve the divergent terms also. The former can be eliminated in the same way. On the contrary, the divergent part of χ cannot be excluded in such a way in both cases. However, this divergent term also disappears in the present mixture. The nuclear potential becomes the following finite expression:

$$U = f^2(\boldsymbol{\tau}^{(1)}\boldsymbol{\tau}^{(2)}/2)\{(\boldsymbol{\sigma}^{(1)}\boldsymbol{\sigma}^{(2)}/3)\phi+\Lambda\chi\}, \quad (4)$$

where $\Lambda=3(\boldsymbol{\sigma}^{(1)}\mathbf{x})(\boldsymbol{\sigma}^{(2)}\mathbf{x})/r^2-\boldsymbol{\sigma}^{(1)}\boldsymbol{\sigma}^{(2)}$, and ϕ and χ are now given by convergent integrals. The function $\chi(r)$ has only a r^{-1} singularity as Schwinger's mixture.[4] The term including ϕ is repulsive for small r, attractive for large r, and it has consequently a shallow minimum in the even state. This feature of ϕ distinguishes the present mixture from Schwinger's. This weakness of the attraction due to ϕ may give a favorable effect to the electric quadrupole moment of deuteron caused by $\Lambda\chi$-term.[2]

The energy spectrum of the nuclear β-decay in the present mixed theory is somewhat different from the result of the pseudoscalar theory. It is given by

$$a(1+b^2-2b/\epsilon)(\epsilon^2-1)^{\frac{1}{2}}(\epsilon_0-\epsilon)^2\epsilon d\epsilon, \quad (5)$$

where $b=(g'/f')(\kappa/K)$. This reduces to the result of the pseudoscalar theory if we put $b=0$. From this and the experiment of Bjerge and Brostrøm[5] we obtain the lifetime of the pseudoscalar meson as follows:[6]

$$\tau_0 = 10^{-5}|J|^2 \quad \text{or} \quad 1.6\times10^{-5}|J|^2 \text{ sec.}, \quad (6)$$

according to $b=0.3$ or 1, where J is the overlapping integral of wave functions (space part) of ^{6}He ^{1}S and ^{6}Li ^{3}S. If we assume $J=0.5$ we have $\tau_0=2.5\times10^{-6}$ or 4×10^{-6} sec., which agrees with experiment. This value of J is quite reasonable. Such an agreement can only be obtained in the pseudoscalar theory, as I pointed out already.[6] Other bearing on experimental facts was well discussed for the two-meson theory by Wentzel.[2]

The detailed report will be published in Progress of Theoretical Physics.

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On the Magnetic Moment of Nucleons According to the Pseudovector Meson Theory

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September 2, 1948

RECENTLY I have been able to eliminate the divergency of the magnetic moment of nucleons as well as that of the two-nucleon potential by assuming a pseudoscalar-pseudovector mixed theory of mesons.[1] In this calculation I assumed that the interaction between pseudovector mesons and nucleons is the 6-vector coupling (g being its constant).

On the other hand, we can equally assume that the interaction is the pseudovector coupling (F being its constant). On the basis of an assumption of both the couplings we have still the negative surplus magnetic moment of the proton. It consists of two terms proportional to F^2 and g^2, respectively, but it does not include a term proportional to Fg. The g^2 term was given previously. The F^2 term is as follows:

$$\mu_P=-(e/2K)(F^2/\hbar c)(2/\pi K)\int_0^\infty[(k^4-K^2k^2)/(k^2+K^2)^2]dk,$$

where $\hbar K/c$ is the mass of the pseudovector meson. This result provides us with criteria for various mixed meson theories.

We consider three kinds of the pseudovector mesons. The first is in interaction with nucleons by the 6-vector (antisymmetric tensor of the second rank) coupling, the second by the pseudovector coupling, and the third by both couplings. These will be referred to as *pvt*, *pvv*, and *pv*, respectively. Further, we refer to the vector and the pseudoscalar mesons as *v* and *ps*, respectively. If we consider a mixture of two fields in order to eliminate divergencies from the magnetic moment of nucleons and the two-nucleon potential, we have eight possibilities as follows: (a) *ps* and *v*, (b) *ps* and *pvt*, (c) *v* and *pvt*, (d) *pvv* and *v*, (e) *pvv* and *ps*, (f) *pvv* and *pvt*, (g) *pv* and *ps*, (h) *pv* and *v*. Cases (a) and (b) were already discussed. In the cases (a) and (f) we can eliminate the divergency from the two-nucleon potential but not from the magnetic moment.[2] In the cases (c) and (e) we can eliminate the divergency from the latter but not from the former. In the case (d) we can eliminate separately from each but not simultaneously from both. The case (g) reduces to (b) in order to satisfy the above-mentioned requirement.

In the last case (h) the conditions are $(G/K_1)^2=5(g/K)^2$ and $F^2=6g^2$ for that requirement, where $\hbar K_1/c$ is the mass of v, and G is a constant of the 6-vector coupling between v and nucleons. Further, K_1 must be smaller than $1.3K$ in order that the surplus magnetic moment of the proton is positive and K_1 must be larger than K in order that the electric quadrupole moment of the deuteron is positive. Then the spherically symmetric part of the two-nucleon potential is repulsive for large r. If we require that it becomes attractive for small r, we must restrict K_1 more severely so that $1.14K<K_1<1.3K$.

We have thus examined all cases of possible mixtures of two meson fields and we see that only two cases (b) and (h) enable us to eliminate the divergencies in question. If we want to know which assumption is in accordance with experiments, the more detailed study is necessary.

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Erratum: A Convergent Expression for the Magnetic Moment of the Neutron

[Phys. Rev. **74**, 2 (1948)]
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IN our previous letter two misprints have occurred which make the text impossible to understand: The formulas defining T^2 and $\theta(T^2)$ are

$$T^2=t^2-r^2,$$
$$\theta(T^2)=0,\quad T^2<0,$$
$$\theta(T^2)=1,\quad T^2>0.$$

Dielectric Behavior of Single Domain Crystals of BaTiO3

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August 26, 1948

AN accurate determination of the dielectric anisotropy of $BaTiO_3$ was, till now, partly hindered by the domain structure of the crystals. More detailed studies of the domain structure of crystals grown from C.P. ingredients indicated that the splitting up into domains is largely due to impurities. Two ways of obtaining single domain crystals seemed possible: increase of purity or the use of mineralizers. The latter way proved to be successful. The resultant single domain crystals were large (0.5 cm) flat plates with the optic (c) axis normal to the major plane.

The dielectric measurements were made by conventional methods except for the precaution of using painted electrodes in order to avoid the splitting up into domains