to show that the static spherical symmetric potential $A(r)$ which belongs to it rises for small distances even more than the Yukawa potential. Therefore the Lagrangians

$$\alpha^{-1}[(1-\alpha A_{,k}{}^2)^{\frac{1}{2}}-1]-\tfrac{1}{2}\kappa^2 A^2$$

and

$$\alpha^{-1}[(1-\alpha\phi)^{\frac{1}{2}}-1] \qquad (1)$$

were examined, and both of them result in finite potentials at $r=0$. The Lagrangian (1) leads to the differential equation

$$A_{,l,l}-\kappa^2 A - A_{,l,l}\alpha(\kappa^2 A^2 + A_{,k}{}^2)+\alpha A_{,k}A_{,l}A_{,k,l} + \alpha\kappa^4 A^3 + 2\alpha\kappa^2 A A_{,k}{}^2 = 0$$

which for large distances (i.e., $\alpha\sim 0$) goes over into $(\Box-\kappa^2)A=0$. For static spherical symmetrical cases (pole at rest) this differential equation has a solution $A(r)$ with $A'(0)=0$, so that terms like $(1/r)A'$ remain also finite. In classical approximation the linear pseudoscalar meson field is the dipole solution of the scalar field;[17] the interaction of two nucleons is described by $(\boldsymbol{\sigma}_2\cdot\nabla)(\boldsymbol{\sigma}_1\cdot\nabla)\varphi$, where

$$(\Box-\kappa^2)\varphi=0,$$

$$\varphi=(\boldsymbol{\sigma}_1\cdot\nabla)\frac{e^{-\kappa r}}{r}=|\boldsymbol{\sigma}_1|\frac{d}{dr}\frac{e^{-\kappa r}}{r}\cdot\cos\vartheta.$$

One can therefore in first approximation, by application of the operator $(\boldsymbol{\sigma}_2\cdot\nabla)(\boldsymbol{\sigma}_1\cdot\nabla)$ to the solution $A(r)$ of the scalar nonlinear field (pole), obtain a neutral nonlinear classical meson potential

$$\beta(\boldsymbol{\sigma}_2\cdot\nabla)(\boldsymbol{\sigma}_1\cdot\nabla)A(r) = \beta\left(S_{12}r\frac{d}{dr}\frac{1}{r}A' + \boldsymbol{\sigma}_1\cdot\boldsymbol{\sigma}_2\frac{1}{r}A' + \tfrac{1}{3}\boldsymbol{\sigma}_1\cdot\boldsymbol{\sigma}_2 r\frac{d}{dr}\frac{1}{r}A'\right), \qquad (2)$$

where $S_{12}=(\boldsymbol{\sigma}_1\cdot\mathbf{r})(\boldsymbol{\sigma}_2\cdot\mathbf{r})/r^2-\tfrac{1}{3}\boldsymbol{\sigma}_1\cdot\boldsymbol{\sigma}_2$ (dipole interaction).

Because the constant α is fixed by the demand that the total energy of the meson field be equal to the self-energy of the nucleon, $Mc^2=938$ Mev, and because, as a consequence of $A(0)$ being finite, no cutoff method has to be applied, β is the only free parameter. κ is already fixed by the mass of the pion. If one puts the potential (2) into the deuteron equation and determines β in such a way that as eigenvalue the binding energy of the deuteron of 2.227 Mev is obtained, then one has, for $\beta=-112$ Mev (a reasonable value in the sense of a potential well depth) and in first very rough approximation, a quadrupole moment of $+5\times10^{-27}$ cm² and a 17 percent ^3D admixture. More exact and more extensive calculations, particularly concerning better solutions of the nonlinear differential equation resulting from (1)—and other similar Lagrangians—are in progress. An extensive report will be given later about the results of these calculations.

The author wants to express his sincere gratitude to the European Office, Air Research and Development Command, for the sponsorship of his work.

[1] S. Machida, Progr. Theoret. Phys. Japan **6**, 904 (1951).
[2] R. Jastrow, Phys. Rev. **81**, 165 (1951).
[3] M. Taketani *et al.*, Progr. Theoret. Phys. Japan **6**, 581 (1951); **7**, 45 (1952).
[4] M. M. Lévy, Compt. rend. **234**, 1744 (1952); K. A. Brueckner and F. Low, Phys. Rev. **83**, 461 (1951); R. Jastrow, Phys. Rev. **91**, 749 (1953).
[5] S. Yukawa (private communication).
[6] P. Banerjee, Indian J. Phys. **27**, 173 (1953).
[7] F. Cap, Progr. Theoret. Phys. Japan **10**, 235 (1953).
[8] W. Heisenberg, Leyden Conference, 1953.
[9] H. Steinwedel, Fortschr. Physik **1**, 7 (1953); M. M. Lévy, Phys. Rev. **84**, 441 (1951).
[10] W. Heisenberg, Z. Physik **113**, 61 (1939); **126**, 519 (1949); **133**, 65 (1952).
[11] W. Heisenberg *et al.*, *Kosmische Strahlung* (Springer-Verlag, Berlin, 1953).
[12] L. I. Schiff, Phys. Rev. **84**, 1, 10 (1951); W. Thirring, Z. Naturforsch. **7a**, 63 (1952).
[13] M. Born, Proc. Roy. Soc. (London) **A143**, 410 (1934).
[14] T. M. Hu, Phys. Rev. **80**, 1109 (1951).
[15] A. March, Acta Phys. Austriaca **1**, 19, 137 (1948); further investigations in progress in Innsbruck.
[16] D. Ivanenko and V. Lebedev, Doklady Akad. Nauk. S.S.S.R. **80**, 357 (1951); **88**, 425 (1953).
[17] W. Pauli, *Meson Theory of Nuclear Forces* (Interscience Publishers, Inc., New York, 1946).

O^{14} Decay and the Fermi Coupling Constant in Beta Decay*†

J. B. GERHART
Palmer Physical Laboratory, Princeton University, Princeton, New Jersey
(Received May 13, 1954)

THE O^{14} positron spectrum has been investigated with a magnetic lens spectrometer and is found to have an allowed shape with end-point energy 1835 ± 8 kev. Remeasurement of the O^{14} half-life leads to a value of 72.1 ± 0.4 sec, about 5 percent lower than reported

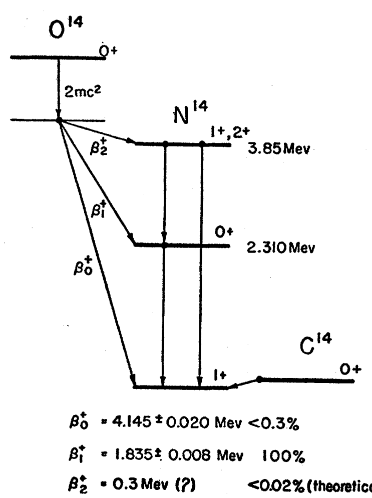

FIG. 1. O^{14} decay scheme.

previously.[1] The ft value for the 1835-kev transition is 3275 ± 75 sec (calculated with the NBS tables[2]). A specific search was made for a ground-state transition (see Fig. 1), but no evidence was found, the percent branching being less than 0.3 percent (corresponding to $\log ft$ greater than 7.3).

In general, for allowed transitions, the equation

$$A = ft\left(\left|\int 1\right|^2 + R\left|\int \boldsymbol{\sigma}\right|^2\right) \quad (1)$$

is valid, where $R = g_{GT}^2/g_F^2$ and $A = 2\pi^3\hbar^7 \ln 2/m^5c^4g_F^2$ are constants. R and A are related to the constants B and x introduced by Kofoed-Hansen and Winther[3] as follows:

$$A = B/(1-x); \quad R = x/(1-x). \quad (2)$$

The 1835-kev O^{14} decay is a $0+ \rightarrow 0+$ transition,[4] i.e., a pure Fermi transition, so Eq. (1) reduces to $A = ft|\int 1|^2$. Hence one of the beta-decay constants g_F may be determined directly provided the nuclear matrix element $|\int 1|^2$ is known.

In terms of the isotopic spin quantum numbers T and T_z,[5]

$$\left|\int 1\right|^2 = T(T+1) - T_zT_z'. \quad (3)$$

For the $O^{14}-N^{14}-C^{14}$ triplet $T=1$, $T_z = -1$, 0, and 1, respectively, and $|\int 1|^2 = 2$. It is of critical importance to realize that this calculation of the matrix element depends solely on the assumption of charge independence of nuclear forces, an assumption common to all determinations of nuclear matrix elements. It does not, however, require any further assumption about nuclear structure such as is needed to calculate the Gamow-Teller matrix element. There is very considerable experimental evidence for the validity of charge independence, especially in the low-lying levels of light nuclei. Radicati[6] and, more recently, MacDonald[7] have calculated the effects of Coulomb forces and configuration interactions in mixing nuclear states. Their findings indicate that for O^{14} these effects should have only an extremely small effect on the value of $|\int 1|^2$.

In view of these facts, it is assumed here that no uncertainty will be introduced in an evaluation of A because of the nuclear matrix element. Thus $A = 6550 \pm 150$ sec and $g_F = 1.374 \pm 0.016 \times 10^{-49}$ erg cm^3. This *direct* determination of the Fermi coupling constant is in reasonable agreement with the various attempts which have previously been made to derive it indirectly from shell-model analyses of allowed decays.[3,8]

Though the Fermi matrix element $|\int 1|^2$ can be computed with a high degree of certainty, the calculation of the Gamow-Teller matrix element $|\int \boldsymbol{\sigma}|^2$ is at present most uncertain. The neutron decay ($|\int 1|^2 = 1$; $|\int \boldsymbol{\sigma}|^2 = 3$), and none other, provides a case where the calculation of $|\int \boldsymbol{\sigma}|^2$ is well founded and almost certainly correct. With the reported ft value for the neutron[9] and the value of A determined from the O^{14} decay, $R = 1.37_{-0.30}^{+0.40}$. Almost the entire uncertainty in R is introduced by the large uncertainty in the neutron half-life.

The author is indebted to Professor R. Sherr and Professor M. G. White for many helpful suggestions in the experimental work on O^{14}, and to Dr. I. Talmi and Professor A. S. Wightman for several fruitful discussions of the theoretical aspects of this work.

* This article is based upon a dissertation submitted to Princeton University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

† This work was supported in part by the U. S. Atomic Energy Commission and the Higgins Scientific Trust Fund.

[1] Sherr, Muether, and White, Phys. Rev. **75**, 282 (1949).
[2] *Tables for the Analysis of Beta Spectra*, National Bureau of Standards Applied Mathematics Series, No. 13 (U. S. Government Printing Office, Washington, 1952).
[3] O. Kofoed-Hansen and A. Winther, Phys. Rev. **86**, 428 (1952).
[4] R. Sherr and J. B. Gerhart, Phys. Rev. **91**, 909 (1953).
[5] E. P. Wigner, Phys. Rev. **56**, 519 (1939).
[6] L. A. Radicati, Proc. Phys. Soc. (London) **A66**, 139 (1953).
[7] W. M. MacDonald, doctoral dissertation, Princeton University, 1954 (unpublished).
[8] See sources cited in reference 4.
[9] J. M. Robson, Phys. Rev. **83**, 349 (1951).

Tensor Forces and the β Decay of C^{14} and O^{14}

B. Jancovici and I. Talmi
Palmer Physical Laboratory, Princeton University, Princeton, New Jersey
(Received May 12, 1954)

The surprisingly long lifetime[1] ($\log ft = 9.03$) of the C^{14} β decay has been known for a long time to be unexplained either by the supermultiplet theory nor by the jj-coupling shell model. Some authors suggested that this high ft value could be explained in intermediate coupling by an "accidental" cancellation of the matrix element involved. Inglis[2] showed that such a cancellation could not occur within a pure p^{-2} configuration if one takes into account central forces and ordinary spin-orbit interaction. Inglis' consideration holds also for a mutual spin-orbit interaction of the type $V_{12} = (\mathbf{s}_1 + \mathbf{s}_2) \cdot \mathbf{l}_{12} V(r_{12})$, as in this case the relevant non-vanishing matrix elements of $\sum V_{ij}$ arise only from the interaction of the holes with closed shells, which is an ordinary (single-nucleon) spin-orbit interaction.

We would like to point out that such a cancellation can occur if tensor forces are also considered. In the following, an interaction

$$H = \tfrac{1}{2}(1+P)[V_c e^{-r/r_c}/(r/r_c) + S_{12} V_t e^{-r/r_t}/(r/r_t)] \quad (1)$$

is assumed between the two p holes, and each hole has also a spin orbit interaction $a(\mathbf{l} \cdot \mathbf{s})$ with the residual