

these transitions may be allowed either by retardation of electron and neutrino waves across the nucleus (i.e.,  $(\mathbf{p}+\mathbf{q})\cdot\mathbf{r}\neq 0$ ) or by the presence in the interaction energy of a small term of order  $v/c = (\text{nucleon velocity})/(\text{velocity of light}) \ll 1$ . The basis for the earlier generalization lies in the "constructive interference" effect of the retardation, represented by the introduction into  $W(\theta)$  of expressions such as  $(p^2+q^2+2pq\cos\theta) \equiv |\mathbf{p}+\mathbf{q}|^2$ .

Thus at the midpoint of the spectrum, with  $E \approx p \approx q$ , the angular dependence of  $W_1$  is most pronounced; the over-all effect of retardation, particularly if  $p \gg 1$ , is to produce a strong similarity between  $W_1$  and  $W_0(1+\cos\theta)$ . On the other hand, the factor  $|\mathbf{p}+\mathbf{q}|^2$  becomes nearly independent of  $\theta$  at the upper and lower ends of the spectrum; here  $W_1$  is therefore more isotropic than at the midpoint, and tends to be similar to  $W_0$ .

Although first forbidden transitions may occur by grace either of the retardation factor  $(\mathbf{p}+\mathbf{q})\cdot\mathbf{r}$  or of the small " $v/c$ " term, more highly forbidden transitions occur only via increasingly high powers of  $(\mathbf{p}+\mathbf{q})\cdot\mathbf{r}$ . Thus the factor  $(1+\cos\theta)$  will enter the midpoint correlation function without exception and to higher powers, so that the preference for forward neutrino emission will become more and more marked; a factor  $(1-\cos\theta)$ , such as will occur for  $W_{ns}$  or  $W_{np}$ , may make  $W(0)=0$  but the "center of gravity" of the emission will still be in the forward direction.

Thus the predicted correlations for allowed transitions depend markedly upon choice of interaction and the correlation effect furthermore appears to possess a simple asymptotic dependence on order of forbiddenness.

<sup>1</sup> F. Bloch and C. Møller, *Nature* **136**, 912 (1935).

<sup>2</sup> J. Halpern and H. R. Crane, *Phys. Rev.* **55**, 1123 (1939). J. S. Allen, *Phys. Rev.* **61**, 692 (1942). J. C. Jacobsen, *Phys. Rev.* **70**, 789 (1946).

<sup>3</sup> E. J. Konopinski and G. E. Uhlenbeck, *Phys. Rev.* **60**, 308 (1941).

### On the Magnetic Moment of the Triton\*

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THE recent determination of the magnetic moment of the triton by Anderson and Novick<sup>1</sup> leads to the somewhat surprising result that the moment is slightly greater than the proton moment. This result is surprising because the moment in a  ${}^2P$  or  ${}^4P$  or  ${}^4D$  state, which are the only states that can be admixed with the  ${}^2S$  state of this nucleus,<sup>2</sup> might be expected to be smaller than the proton moment. Therefore, one might expect that any admixture of these states would lead to a smaller moment than that in the pure  $S$  state. It should be pointed out first that, although this statement is correct for the  ${}^2P$  and  ${}^4P$  states, in a pure  ${}^4D$  state the moment need not be less than the proton moment because this state may be formed by combining a wave function which is symmetric for the interchange of  $\rho$  and  $\mathbf{r}$  and an anti-symmetric function.<sup>3</sup> Here  $\rho$  and  $\mathbf{r}$  are the distance between the neutrons and the distance from the center of gravity of the neutrons to the proton, respectively. The interference between these symmetric and anti-symmetric functions may lead to a

very high moment if the wave function contains states in which the individual particles have sufficiently high orbital angular momenta. However, it seems probable that this latter requirement is not satisfied since the orbital angular momenta of the individual particles probably are small in the ground state. Under this condition the moment in the  $D$  state is less than that of the proton.

It is still possible to account for the moment of the triton by introducing an admixture of  ${}^2P$  and  ${}^4P$  states since there are terms in the expression for the magnetic moment which arise from interference between the  ${}^2P$  and  ${}^4P$  states, between the  ${}^2S$  and  ${}^2P$  states, and between the  ${}^4P$  and  ${}^4D$  states. The signs of these terms depend on the relative phases of the wave functions so that they may be positive. An estimate of their order of magnitude can be made if one makes assumptions consistent with keeping the orbital angular momenta of the individual particles as small as possible and at the same time assumes that the radial parts of the various wave functions are in phase throughout the nucleus. Then it is found that a 6.7 percent increase of the triton moment over the proton moment can be obtained only if the  ${}^2P$  and  ${}^4P$  state amplitudes are greater than the  $D$  state amplitude. The  $S$  state probability is a maximum if the  $D$  probability is taken to be zero, the  ${}^4P$  probability to be 8 percent, and the  ${}^2P$  probability 20 percent. This rather startling conclusion might be avoided by dropping the above assumption concerning the orbital angular momentum of the individual particles, but it appears that very high configurations indeed would be required to explain the experimental result.

If one assumes that the triton wave function contains about 20 percent  ${}^2P$  state, 8 percent  ${}^4P$  state and no  ${}^4D$  state, then one would draw the same conclusion for  $\text{He}^3$  and it would be anticipated that the magnitude of the moment of  $\text{He}^3$  would be about 4.0 percent greater than the numerical value of the neutron moment.<sup>3</sup> A measurement of the moment of  $\text{He}^3$  would be most valuable for obtaining further information concerning the admixture of states.

The details of these calculations, including a discussion of the other possible ways of compounding a ground state consistent with the observed magnetic moment, will soon be submitted for publication.

\* This work has been carried out under the auspices of the Atomic Energy Commission. It was submitted for declassification on January 24, 1947.

<sup>1</sup> H. L. Anderson and A. Novick, *Phys. Rev.* **71**, 372 (1947).

<sup>2</sup> E. Gerjuoy and J. Schwinger, *Phys. Rev.* **61**, 138 (1942).

<sup>3</sup> R. G. Sachs and J. Schwinger, *Phys. Rev.* **70**, 41 (1946).

### Erratum: Note on the Scattering of Radiation in an Inhomogeneous Medium

[*Phys. Rev.* **71**, 268-269 (1947).]

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THE term  $\left[ \left(1 + \frac{z}{r}\right)\alpha + \frac{x\beta}{r} + \frac{y\gamma}{r} \right]$  in Eqs. (6) and (7) should be changed to  $\left[ \left(1 + \frac{z}{r}\right)\gamma + \frac{\alpha x}{r} + \frac{\beta y}{r} \right]$ . In the second integral of Eq. (6)  $d\omega'$  should be added.