Decay of K^{40}

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THE energy of the γ-rays emitted by natural radioactive K^{40} was measured by the absorption method, with copper and lead used as absorbers. We found an energy of 1.5 Mev in accord with the value 1.54 Mev obtained by Wäffler and Hirzel.[1] This energy, however, is a little higher than the upper limit 1.35 Mev of the continuous β-spectrum[2] and so it seemed difficult to associate this γ-ray with the β-transitions. On the other hand, positron emission or K-capture could take place to account for the great abundance of A^{40}. Evidence for a K-capture process was given[3] recently, and no positron activity has been detected. We undertook β–γ coincidences to show that the γ-rays should be associated with the K-capture process. Measurements were taken with a precision of 1 percent, and no coincidences were obtained. These experiments show that no γ-rays can be associated with the β-transitions and that, therefore, the nucleus of Ca^{40} is not left in an excited state, showing that the disintegration scheme proposed by Wäffler and Hirzel is a correct one.

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2 Dzelepow, Vorobjov, and Kopjova, Comptes rendus (U.R.S.S.) **52**, 121 (1946).
3 E. Bleuler and M. Gabriel, Helv. Phys. Acta **XX**, 67 (1947).

The Collision of Neutrons with Deuterons and the Reality of Exchange Forces

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IN a recent letter under the above title, Massey and Buckingham[1] have presented some experimental evidence for the reality of exchange forces between a neutron and proton. It is the purpose of this note to point out that experimental evidence exists which does not confirm their argument.

In Fig. 2 of Massey and Buckingham's letter (which unfortunately was misplaced to page 563 of the April 15 issue of the Physical Review), a comparison is made between the theoretical predictions for the total elastic cross section for the scattering of fast neutrons by deuterons as a function of neutron energy and the experimental observations of Ageno, Amaldi, Bocciarelli, and Trabacchi.[2] This comparison is repeated in Fig. 1 of this letter. In addition, the experimental results of Nuckolls, Bailey, Bennett, Bergstralh, Richards, and Williams[3] are shown.

The complete agreement between the results of Ageno *et al.*, and Nukolls *et al.*, for neutrons of 4 Mev is evident. Since the experimental techniques used by the two groups were so greatly different, there is reason to feel confident about the reality of the experimental results in the energy region up to 6 Mev. It is in just this region that agreement between experiment and Massey and Buckingham's theory might be expected. As these authors point out, their theory would be expected to give lower values for the cross section than the measured values for 12- and 14-Mev neutrons,

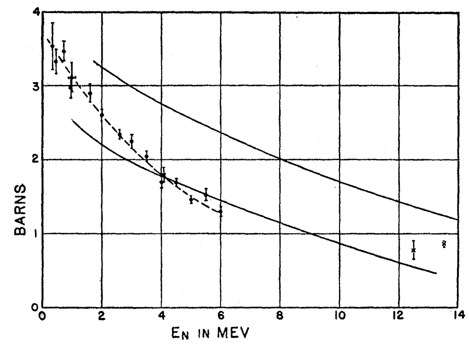

FIG. 1. Comparison of the observed and calculated total cross sections for the collision of neutrons with deuterons. The upper and lower full curves are calculated by Massey and Buckingham[1] on the respective assumptions of ordinary and exchange forces. The crosses are the experimental results of Ageno *et al.*[2] The circles are the results of Nuckolls *et al.*[3] The vertical dashes are the observational errors given by the experimenters.

since the additional contributions to the cross section for higher states of angular momentum have been neglected.

The probable conclusion that one can draw from the comparison in the lower energy region is that the interaction potential chosen by Massey and Buckingham does not represent the existing experimental facts. Consequently, the total cross section for neutron-deuteron scattering cannot be interpreted on the basis of their theory as strong evidence for the reality of exchange forces.

1 H. S. W. Massey and R. A. Buckingham, Phys. Rev. **71**, 558 (1947).
2 M. Ageno, E. Amaldi, D. Bocciarelli, and G. C. Trabacchi, Nuovo Cimento **1**, 253 (1943); Phys. Rev. **71**, 20 (1947).
3 R. G. Nuckolls, C. L. Bailey, W. E. Bennett, T. Bergstralh, H. T. Richards, and J. H. Williams, Phys. Rev. **70**, 805 (1946).

Interaction between Meson and Nucleon

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IT is known[1,2] that the Proca equations for a charged meson, (spin $\hbar$), moving in a coulomb field do not have a complete set of acceptable solutions. This has been shown[1,3] to be due to the appearance of an inverse cube, (r^{-3}), attractive potential in the second-order wave equations. The results of reference 2 indicate that this potential produces spin-orbit coupling.

Since the theory applies to a point charge, the central force may be thought of as arising on an "elementary nucleon," i.e., an electron of nucleonic mass. If we assume this hypothetical nucleon to have spin $\frac{1}{2}\hbar$, and consider the meson-nucleon states of total angular momentum $\frac{1}{2}\hbar$, the disastrous potential appears for those meson waves, ($\mathbf{U}$, U_0), in which the space components, $\mathbf{U}$, contain both S and D waves. These waves are coupled in such a way that as $r\rightarrow 0$, the eigenvalues of the operator d^2/dr^2 obey the condition

$$d^2/dr^2 \rightarrow \pm\sqrt{2}e^2/\mu c^2 r^3 \text{ as } r\rightarrow 0, \tag{1}$$

where μ is the mass of the meson. The essence of this formulation of the difficulty is presented in reference 3.

As shown by Landau,[4] the Proca equations are prob-