Letters to the Editor

Further Confirmation of the Montgomery Theory of Counter Discharge

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July 14, 1941

THE Montgomery theory[1] of counter discharge makes it possible to predict the dependence of pulse size (maximum negative potential change of the counter wire) upon wire capacity and counter length under conditions where it is safe to assume that the discharge starts simultaneously at all points in the tube. The picture is particularly interesting if, as we vary counter length and wire capacity, the discharge passes from what has been termed a "slow" breakdown to a "fast" breakdown (for non-self-quenching gas mixtures). It follows from the discharge mechanism that for a given cylinder potential and wire capacity there is a length l_e such that for all $l \leqslant l_e$ the pulse size is constant and equal to the over-voltage on the counter. For values of $l > l_e$, $V = l\alpha/C$, where α is the charge per unit length in the positive ion sheath necessary to quench the discharge at the assigned cylinder potential. For $l < l_e$ the counter is breaking multiply in each discharge and the succession of these multiple breaks produces what has been called a slow breakdown. For $l > l_e$ the counter is "overshooting." Here there is only one break in the discharge and the counter has been referred to as having a fast breakdown.

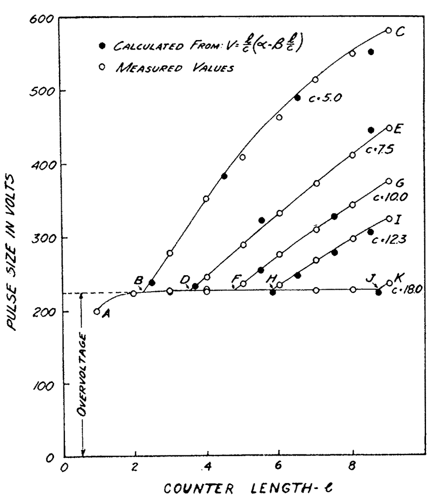

FIG. 1.

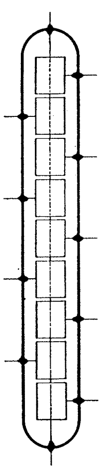

FIG. 2.

FIG. 1. Maximum potential change of counter wire and its variation with counter length for a series of wire capacities. C expressed in farads in the empirical expression, $\alpha = 5.2 \times 10^{-10}$, $\beta = 1.2 \times 10^{-22}$. Low value of A due to end effect in short counter.

FIG. 2. Counter cylinder composed of nine separately insulated segments. The number of segments above (here 225 volts above) starting potential defines the effective counter length, other segments being at a value below the starting potential. Thus by changing the potential of the segments the effective counter length may be changed *without altering capacity of the wire system.* Capacity changes were made by adding condensers between wire and ground. Voltage swing measured using a weakly coupled electrometer tube and grounding counter wire with key after each discharge. Counter filled with 9 cm argon-oxygen mixture.

If the discharge does not start at all points in the tube within a short time interval (10^{-7} second) after it has started at one point, the linear charge density will not be constant over the counter length and the picture, although unaltered in form, is modified somewhat in detail to allow for the finite time required for the discharge to propagate itself from one point to another. Simple considerations combined with direct observations on the time variation of counter wire potential[2] indicate that this time of propagation is only important in modifying the picture for small C and large l.

Figure 1 is a family of curves showing the variation of pulse size with l for a series of values of C. Here great care was taken in the experimental procedure to obtain low values of C, *variation of* l *without altering* C, and a true value of the maximum negative voltage when no charge is allowed to leak from the counter wire. Refer to Fig. 2 and its caption for a description of the procedure.

In Fig. 1, ABC is the characteristic for $C = 5.0\mu\mu f$, ADE for the wire capacity C equal to $7.5\mu\mu f$, AFG for $C = 10.0\mu\mu f$, and so on. Examination of this family reveals that the lengths AB, AD, AF, AH, AJ (values of l_e) are proportional to C. The family may be represented satisfactorily by the relation $V = \text{Constant} = \text{over-voltage}$ for values of $l \leqslant l_e$ and $V = (l/C)[\alpha - \beta(l/C)]$ for values of $l \geqslant l_e$. Here α is the constant charge per unit length referred to above and experimentally obtained for small l and large C. Thus to a first approximation propagation time reduces the average charge per unit length by an amount proportional to l/C.

The experimental picture obtained agrees with the picture presented by the theory, altered only to allow for propagation times of the order of 10^{-7} second. The authors have been unable to reconcile the results obtained with any picture of the discharge differing materially from that presented by this theory.

[1] C. G. Montgomery and D. D. Montgomery, Phys. Rev. **57**, 1030 (1940).
[2] W. E. Ramsey, Phys. Rev. **57**, 1022 (1940).

New Reactions in Nickel

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August 7, 1941

KONOPINSKI has shown[1] that the half-lives of many radioactive nuclei show certain regularities when expressed as functions of their atomic numbers. These regularities occur in families of nuclei that differ only in the number of alpha-particle units that they contain. If the logarithm of the period is plotted against the atomic number for a given family, the resulting curves may be interpolated to make predictions about unknown and uncertain members of the family.

Curves of the families containing radioactive isotopes of nickel are drawn in Fig. 1. According to the predictions of these curves, Ni^{57} should have a half-life of about 2 minutes and Ni^{59} a half-life of about 36 hours. A period of 36 hours

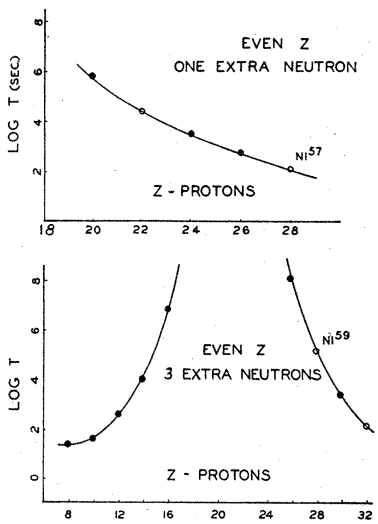

FIG. 1. Log of half-life T as a function of atomic number Z.

is known in nickel but it has been assigned[2] to Ni^{57} since such an activity was not observed with slow neutron or deuteron bombardment of nickel.

In the present work the 36-hour activity was produced by a fast neutron reaction on nickel. In addition, two other periods of 2 minutes and 2.6 hours were observed. The 2.6-hour activity has been definitely assigned[3] to Ni^{63}. Also, alpha-particle bombardments of iron showed the 2-minute and the 36-hour activities. The activities are then to be assigned to Ni^{57} and Ni^{59}, since the stable isotopes of iron which could produce radioactive nickel by the (alpha, n) process are Fe^{54} and Fe^{56}. Long bombardments of nickel by slow neutrons produced a weak 36-hour activity which was followed over 4 half-lives. This period was also produced by deuteron bombardments of nickel. In both cases the activity was a positron activity of 36 hours half-life, and must be due to the formation of Ni^{59} by Ni^{58} (n, gamma) and Ni^{58} (d, p) reactions.

The establishment of Ni^{59} to have a half-life of 36 ± 1 hours leads to the assignment of the 2 minutes and was produced by a Fe^{54} (alpha, n) and a Ni^{58} (n, $2n$) reaction. Chemical separations for nickel were made throughout.

[1] Konopinski and Dickson, Phys. Rev. **58**, 949 (1940).
[2] Livingood and Seaborg, Phys. Rev. **53**, 765 (1938).
[3] Heyn, Physica **4**, 1224 (1937).

The Antisymmetrical Interaction in Beta-Decay Theory

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August 2, 1941

THE process of beta-disintegration can be considered as a four-particle process, i.e., a process in which four particles are created simultaneously. Thus, e.g., the process leading to the emission of an electron can be considered as the creation of a proton, a neutrino, and an electron in positive energy states, and of a neutron in a negative state.

If one adopts this point of view, it appears natural to look for interactions which are either totally symmetric or totally antisymmetric in the four particles. We found that a relativistically invariant interaction which does not contain any derivatives of wave functions[1] cannot be symmetric in the particles. There is, however, a totally antisymmetric relativistically invariant interaction which can be used instead of the "vector interaction" originally proposed.[1]

In terms of the customary five invariants (heavy particle covariants contracted on light particle contravariants) the antisymmetric interaction is a sum of scalar, axial vector and pseudoscalar invariants. An axial vector interaction has already been introduced by Gamow and Teller[2] as an alternative to the polar vector in order to allow beta-transitions in which $\Delta i = \pm 1$ and 0 (but no $0\rightarrow 0$). The antisymmetric interaction thus permits $\Delta i = 0$, ± 1, *including* $0\rightarrow 0$ and with stronger transitions with $\Delta i = 0$ than in the pure axial vector interaction. There is no change of parity in the allowed transitions.

Certain qualitative aspects of allowed transitions under the antisymmetric interaction can be seen at once. There is an additional cause for the transitions $\Delta i = 0$. In consequence thereof, the theory gives a larger ratio for the lifetimes of the light $4n+2$ nuclei to the lifetimes of the light odd nuclei than the Gamow-Teller theory gave.[3] This increases the discrepancy in the case of He^6 but decreases it in most other cases. However, the theory does not help in understanding the great irregularity in the lifetimes of the $4n+2$ nuclei. On the other hand, the theoretical ratio of the number of transitions to excited and ground states of the odd nuclei studied by Grönblom[4] is improved in every case.

Forbidden transitions in this theory are qualitatively the same as under the axial vector interaction. First forbidden spectra are of two types: one identical with allowed spectra in shape and due to the finite velocity of the nuclear particles; the other distinctly different in shape and arising from the finite radius of the nucleus. The change of nuclear spin is always zero for the first type (including $0\rightarrow 0$) but in the second type the spin may change by ± 1 or ± 2. All the first forbidden transitions incur a change in parity.

The nature of the departure of forbidden spectra from the form of the allowed spectra can be determined as follows. An electron with the full amount of energy available in a given process has a shorter wave-length than a neutrino with the full amount available to it because of the finite rest energy of the electron. Thus the forbidden spectrum of any degree, if proportional to a power of $r_{\text{nuc}}/\lambda_{\text{light part}}$, will tend to be more intense at high electron energies than at low. The obvious effect on the Kurie plot is to make it concave toward the axes at high electron energies. None of the carefully measured spectra are of this character, and, in fact, in most cases the tendency is to the opposite curvature.

Careful measurements on the spectra of Na^{24} and P^{32} by Lawson[5] yield Kurie plots which are good straight lines at the high energy end. According to the present theory it would appear that these transitions are either allowed or