Letters to the Editor

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Temporal Growth of Current between Parallel Plates

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(Received July 5, 1956)

IN the theory of current growth between parallel plates in a gas (the Townsend discharge), an important case is that in which there are two secondary processes in operation at the cathode, *viz.*, electron generation by photons (δ process) and by positive ions (γ process). A well-known problem concerning this system is the calculation of the cathode electron current at any time (in absence of space charge distortion) produced by exposing the cathode to a constant external illumination from time zero onwards, the gas being initially free from charged particles. If αd (where α is the first Townsend coefficient and d the plate separation) has a typical experimental value of the order of ten, the exact solution, either in the form in which I originally gave it,[1] or in the equivalent form in which I have since given it,[2] is, owing to its absolute accuracy, rather cumbersome if applied rigorously up to large multiples of the electron transit time. Writers have therefore directed more attention to my approximate formula,[1] and particularly to the special case in which (by taking one of the secondary coefficients, say γ, to be zero) it is applied to the simpler problem in which there is only one secondary process. Auer,[3] in a study of this simpler problem, has recommended a slight modification of my approximate formula for it; but, for reasons which I have pointed out,[2] the modification which he recommended is not desirable.

Auer has recently proposed[4] two new formulas (still for the special case of γ zero). One is proposed as a new equivalent form of the exact solution, and the other as an approximation to it. He obtains these formulas by a procedure which is interesting, but which contains a mathematical fallacy. For typical values of αd of order ten, they are in consequence quite wrong, except in the first electron transit time. After only about three electron transit times they are not even of the right order of magnitude. Suppose, for example, that, with αd about ten, we consider a slightly overvolted gap, (or one which is slightly undervolted and in which the electron current at the cathode attains, in reality, an amplification of, say, a hundred, after an infinite time). In all such cases the amplification after only three electron transit times will, in reality, be only about four; but Auer's new formulas predict an amplification or order ten to the power of eight. If the over (or under) voltage is increased, the predictions remain equally unrealistic.

The incorrectness of Auer's new formulas is due to an erroneous mathematical argument, not employed in his previous paper. In setting up Eq. (4) of his new paper, he has tacitly assumed that the quantity which he calls h has to be continuous at the positive integral values of ξ. But actually it is f that has to be continuous. As ξ passes through an integral value, the n in his Eq. (2) changes suddenly by unity, and h must change suddenly to prevent f from changing. Applying this at $\xi=1$, and taking αd (and hence also Auer's q) to be of order ten, it will be found that as ξ passes through unity, h falls suddenly from a value unity to an extremely small fraction. As ξ passes on from 1 to 2, h declines progressively [in accordance with his Eq. (3) which is valid at all nonintegral values of ξ], and at $\xi=2$ it suddenly becomes even smaller; and so on. Hence the values of h given in his Table I ($q=10$), being calculated from his erroneous equation (4), are of much too large an order at all ξ's greater than unity; and thus the unrealistic predictions of his formulas are not surprising.

[1] P. M. Davidson, Brit. J. Appl. Phys. **4**, 170 (1953).
[2] P. M. Davidson, Phys. Rev. **99**, 1072 (1955).
[3] P. L. Auer, Phys. Rev. **98**, 320 (1955).
[4] P. L. Auer, Phys. Rev. **101**, 1243 (1956).

Hyperfine Structure of the Metastable State of Singly Ionized He^3†

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(Received July 23, 1956)

THE nuclear and electrodynamic information that can be obtained from the study of atomic hyperfine structure is limited in part by the accuracy of atomic wave functions. In the case of He^3 and possibly for other low-Z nuclei, this limitation can be avoided by ionizing the atom and thereby forming a hydrogen-like system whose wave function is known exactly. We describe an ion beam method for determining the hyperfine structure of the $2S_{\frac{1}{2}}$ state of ionized He^3 and report a preliminary value for this quantity.

In the present experiment He^3 atoms are ionized and excited by electron bombardment. At a bombarding energy of 250 ev approximately one percent of the ions is in the metastable $2S_{\frac{1}{2}}$ state. The ions are drawn out of the ion source and accelerated to 20 ev. The