As the new melting curve, corrected somewhat arbitrarily for the mechano-caloric heat leakage, cuts the temperature axis about 0.4°K when extrapolated, it seems reasonable to check for the triple point of helium (the "ordinary" triple point) in the magnetic region of cooling.

* This work is carried out under a grant from the National Research Council of Canada.

† A brief account of this work was given at the meeting of the Physics Section of the Royal Society of Canada on June 3, 1952.

‡ After writing this letter, the author read in a recent article in the Physical Review [P. Closmann and R. T. Swim, Phys. Rev. **86**, 576 (1952)] that Dr. K. Mendelssohn, F. R. S., suggested an experimental investigation of the thermal gradient in the "helium wire." The experimental results reported there are in complete agreement with views expressed in this letter.

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Geiger-Nuttal Relation and α-Ray Spectra

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ATTEMPTS have been made by Berthelot and others[1,2] to improve the original Geiger-Nuttal[3] curves by choosing the "same charge number Z," instead of the "same neutron-excess" as the basis for joining the points. However, recently Perlman *et al.*[4] showed that in fact all nuclei except the even-even ones deviate considerably from the above linear relation. Besides, the deviations of the spectral components of lower intensities are usually more serious.

In view of this well-known difficulty in correlating different elements, we consider here each alpha-spectrum (i.e., each element) individually with regard to the relation $\log\lambda$ *vs* decay energy E. Partial α-decay constants λ_k are plotted against the corresponding decay energies of all the spectral components, and the points for the "same Z and same mass-number A" have been joined. The curves obtained will be discussed in detail in a separate paper, while some typical ones are shown here in Fig. 1

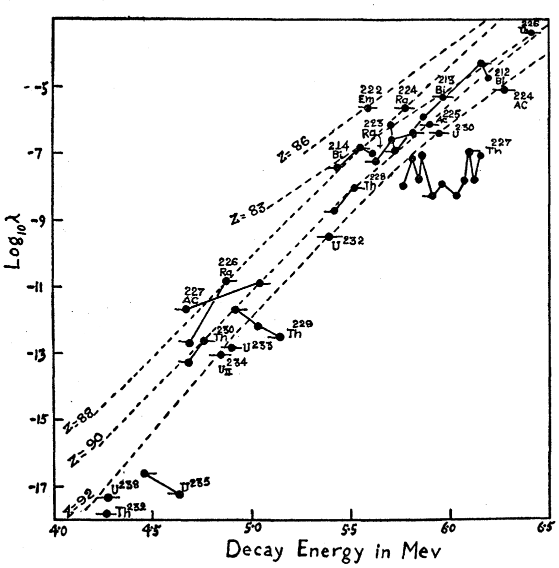

FIG. 1. A dotted line is the usual Geiger-Nuttal curve for the same Z, while a solid line represents a $\log\lambda_k$ *vs* E curve for an α-spectrum. -●- represents an α-spectrum with single line. ●- represents a maximum intensity group, -● a minimum intensity group, and ● means a group of intermediate intensity of an α-spectrum.

(solid lines), along with the usual Geiger-Nuttal curves (dotted lines).

It may be seen from the solid line curves in the figure that in α-ray spectra, instead of the positive gradient of the Geiger-Nuttal relation (i.e., a linear increase of $\log\lambda$ with increasing E), both positive and negative trends exist in the variation of λ with E. In this respect striking similarity is exhibited by all the fifteen α-spectra known at present. The simplest spectra are the doublets, which give either the positive trend only (e.g., Th spectra) or the negative trend (e.g., U^{235}). For the triplet spectra, a positive trend is followed by a negative one (e.g., Bi^{214}) or vice versa, while in the case of the Th^{229} triplet only a negative trend exists. For more complex spectra (a typical example being Th^{227} in Fig. 1), regular alternations of the two opposite trends occur in general.

Now from a theoretical standpoint these negative trends present serious difficulties. For the α-decay theories of Gamow[5] and others gave λ as a function of Z, nuclear radius r_0, and decay energy E. In an α-sprectrum, since Z and r_0 $(\propto A^{1/3})$ are constant, λ becomes an exponential function of E alone, giving only a steep rise in λ with increasing E. From the above discussion it follows that some compensation of the increasing effect of E on λ should be postulated. In the paper to be published we have theoretically discussed the nonlinear curves for α-spectra in the light of various recent suggestions, *viz.*, nonzero values of azimuthal quantum number (Gamow[5]) or delay in formation of the α-particle (Perlman *et al.*[4]), etc., which have been made in connection with the stated deviations from the Geiger-Nuttal relation. It will be seen that none of these is very useful in the case of α-spectra.

It may be pointed out that so far in α-decay theories, the field outside the nucleus has been assumed to be purely Coulombian. However, when the alpha-particle is just emitted, a short-range Yukawa field, say V', would operate between the four nucleons of the emitted α-particle and those on the surface of the residual nucleus. So if the resultant field outside the nucleus is taken to be $\{2(Z-2)e^2/r-V'\}$, the wave equation for the α-particle would be

$$\Delta\psi+(8\pi^2M_\alpha/h^2)[E+V'-2(Z-2)e^2/r]\psi=0.$$

Obviously, in the final formula for λ, V' would be involved. Now what form of V' would lead to a fluctuation of λ or to the observed negative trend is a matter for further study. It is, however, probable that since V' is spin-dependent, the excitation shells within the nucleus of the four nucleons forming the alpha-particle may have different spin values and affect V' differently in the different cases, as observed.

Finally, I wish to express my gratitude to Professor M. N. Saha, F. R. S., for his kind interest in this work and for his encouragement. I wish also to thank Dr. D. Basu for the facilities and encouragement given.

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Shock Waves in Low Pressure Spark Discharges*

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ASSUMING that an expansion of hot gas follows the passage of a columnar current through a gas at low pressure, a shock wave should precede the advancing hot gas front (through the quiescent medium surrounding the column). Treating the expanding gas as a moving piston and measuring its velocity of advance by means of its own luminosity,[1] the Rankine-Hugoniot equations will give the velocity of advance of the shock front.

We have found two situations in which the shock fronts make themselves visible by the excitation they produce, and computations of the sort suggested above verify the correctness of this description of the expanding spark channel. A mirrorgram which shows both situations at the same time is shown in Fig. 1. In the first case the shock fronts become self-luminous upon reflection from an obstacle to the flow so that the original shock path can be inferred by the point at which the reflection occurs. In the

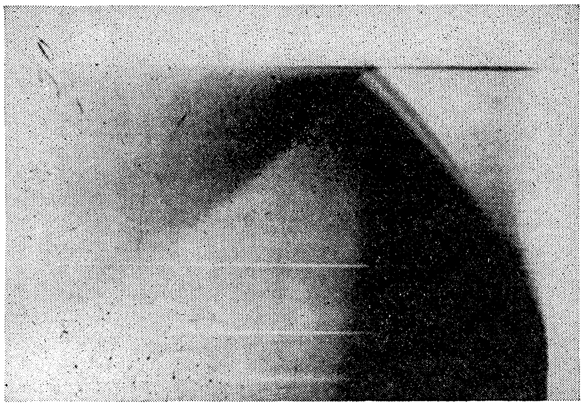

FIG. 1. Mirrorgram showing expanding luminous gas, preceded by a luminous shock front which reflects with intensified luminosity at a piston and then intersects the oncoming luminous gas flow.

second case, with a careful choice of discharge pressure, the shock waves are directly visible in their own light. Argon was the gas employed.

Table I gives among other things a comparison of the measured shock velocities with the computations from the luminous gas flow velocity. Also included are a few computations of temperature and pressure behind the shock in the case of both the original and the reflected shock, computed on an ideal gas law. These latter figures give some idea of the origin for the observed luminosity. It is probable that we have to deal here almost exclusively with Saha temperature excitation processes.

TABLE I. Comparative thermodynamic data for spark expansions. W=capacitor energy; p_0=initial pressure; U_c=contact velocity (luminosity); U_s=calculated shock velocity; $U_s{}^1$=measured shock velocity; p_1=shock pressure; T_1=shock temperature; p_2=reflected shock pressure; T_2=reflected shock temperature. Units used are joules, mm Hg, km/sec, 1000°K.

W	p_0	U_c	U_s	$U_s{}^1$	p_1	T_1	p_2	T_2
30	10	1.6	2.2	2.0	560	4.5	2100	10
120	0.8	4.0	5.4	5.1	280	27	1600	64
10	17	1.0	1.4	···	380	1.9	1900	4.2
120	17	2.1	2.8	2.9	···	···	···	···
120	2	2.5	3.4	4.0	···	···	···	···
120	0.3	2.65	3.5	3.5	···	···	···	···
120	3.4	1.35	1.6	2.7	···	···	···	···
120	1.1	2.60	2.9	3.6	···	···	···	···

Examination of a series of mirrorgrams in which controlled reflection of the advancing gas was studied shows that at high initial densities the description given above is adequate, i.e., an optionally luminous shock front precedes an expanding, hot, luminous gas. At low densities, however, this description is inadequate, and a strongly self-luminous shock front is by far the principal manifestation of the expansion. This result explains the anomalies which are present in our earlier reports,[1,2] where we have described the expanding post-discharge luminosity of the spark as being in some cases a ball of flame and in others more nearly a luminous tongue or jet. We believe that this transition in the post-discharge disposal mechanism of surplus excitation energy, which occurs in the vicinity of an initial density of 5×10^{16} particles per cc, may well be a critical point for the definition of the term, low pressure spark discharge.

Recent work by Kantrowitz[3] and by Laporte,[4] has shown the possibility of producing luminosity even in conventional shock tubes.

The authors desire to express their gratitude to Dr. Otto Laporte for his valuable suggestions concerning this work.

* Supported by the ONR.

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Cavitation Effect in Helium II*

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DURING some work on the properties of helium at temperatures in the magnetic region of cooling, apparatus was constructed (Fig. 1) containing a few grams of a powdered paramagnetic salt (iron ammonium alum) in a glass capsule 8 mm in diameter, enclosed in a vacuum jacket. The capsule and the jacket could be pumped independently with a pumping speed of up to 2 liters per second, and provision was made for the condensation of helium in the capsule. Usually the liquid helium meniscus in the capsule was kept just above the level of the salt. The top of the salt and the helium level could be observed through a gap in the silvering of the Dewars and the capsule. The salt was cooled by adiabatic demagnetization from a maximum field of 10,000 oersteds and an initial temperature of about 1.2°K.

The effect observed with this apparatus was that, invariably, after demagnetization, the meniscus of the helium in the capsule

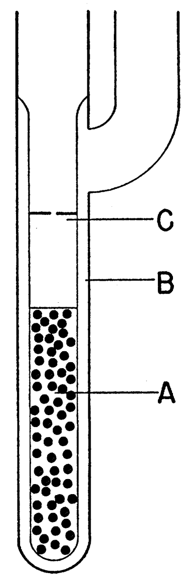

FIG. 1. A schematic diagram of the capsule and vacuum jacket. A—powdered paramagnetic salt, B—vacuum jacket, C—membrane.

suddenly rose above the salt, as high as 2 cm in some cases—this apparent volume increase being comparable with the amount of helium present in between the grains of the powdered salt. After one or two seconds, the meniscus dropped again and then immediately rose, going through several oscillations. When demagnetization was performed in several stages, the time of the rise of the meniscus correlated with each step of demagnetization.

In a series of experiments, a thin glass membrane, with a pinhole of diameter varying from 100 to 300μ, was introduced as a partition in the tube connecting the capsule with the pumping system. With this arrangement, the initial temperature of the capsule could be lowered to about 0.8°K. When the membrane was 6 cm above the level of the salt, a much diminished effect (1 mm) was observed. When the membrane was 3 cm above, no rise of the meniscus could be observed, but the surface of the helium during every demagnetization appeared very confused, showing lively ripples due to vigorous undercurrents. In all cases, however, if the pumping of the capsule was stopped a few seconds before demagnetization, the effect reappeared.

As no other sources of helium comparable with the amount in the salt are present in the system, the necessary conclusion is that the liquid helium is expelled from the powder. In this connection, it may be mentioned that the effect was absent when the powdered

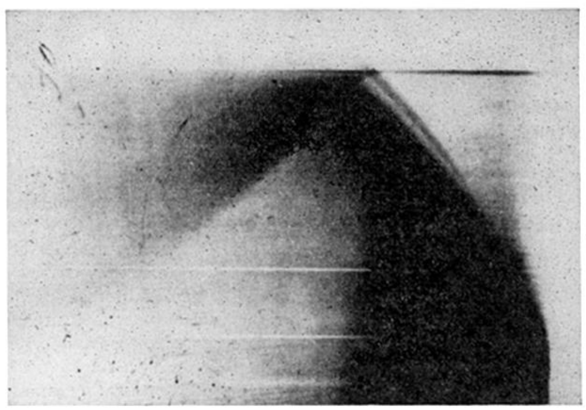

FIG. 1. Mirrorgram showing expanding luminous gas, preceded by a luminous shock front which reflects with intensified luminosity at a piston and then intersects the oncoming luminous gas flow.