surement of the viscosity of an expanded liquid by the Stokes method is possible. The problem in further investigations is to improve the accuracy of the necessary measurements and to explore methods of extending the temperature interval in which the expanded liquid exists.

1 C. R. Bloomquist and A. Clark, Ind. Eng. Chem., Anal. Ed., 12, 61 (1940).

2 Tekhn. ents., Spr. fizich., khimich. i tekhnologich. velichin [Technical Encyclopedia, Handbook of Physical, Chemical and Technological Data], 5, 10.

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Translated by W. F. Brown Jr.
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Concerning the Possibility of an Experimental Investigation of the Structure of the Electron

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IN connection with successes in the construction of different electron accelerators, the latter find greater applications as the activating agent in investigations of electric charge distributions in atomic nuclei. In particular, the study of elastic scattering of 100, 188 and 236 mev electrons by protons at rest permitted the determination of the mean square radius of the proton[1].

All these computations and interpretations of experimental results, however, were based on the assumption of a dimensionless electron. The question of charge distribution inside the electron is important not only from the point of view of using this particle for investigations of structures of heavy nuclei, but is also independently of interest in physics. An experimental solution of this question makes it necessary to have a source of ~ 40 bev electrons for the case of the immovable electron target. Besides, in view of the small value of the effective cross section, currents of the order of several amperes are required for a responsible frequency of observation.

The choice of electron energy is determined by experimental capabilities to determine the angular distribution of the differential cross section in elastic scattering of electrons by electrons computed for two extreme cases: 1) the electron is treated as a mathematical point; 2) the electron has the classical radius $r_0 = e^2/mc^2$. The effective cross section for the first case is determined by the known Meller formula[2]. Quantum electrodynamic computations of scattering of extended electrons by electrons was carried out by M. A. Markov and I. V. Polubarinov. Accounting for the extension of the electron consisted of replacing the Hamiltonian of local interaction by the Hamiltonian of interaction with non local current, which formally lead to a change in the propagation function of the virtual photon. The dependence of the differential cross section on the scattering angle in the center-of-mass system is shown graphically in the Figure for the two types of selected form factors. It is seen from the Figure that the ratio of scattering cross sections at these energies γ (= E/mc^2) is quite distinguishable experimentally.

At the present time there are no known methods of developing accelerators for obtaining electrons of such high energy (> 40 bev) especially for currents in amperes.

The possibility of conducting an experiment as indicated above is based on utilizing the principle of the ring phasotron, proposed by Kolomenski, Petukhav and Rabinovich[3] back in 1953. In this accelerator the magnetic field remains constant in time, but a small width of the magnetic path is preserved due to high gradients (large n) and the introduction of sectors with reverse direction of the magnetic field. The constancy of the magnetic field permits to apply the principle of charge accumulation in the limiting energy orbit and, in view of the repeated passage of the particles through the same meeting place, permits to circumvent the second difficulty connected with the need for high currents.

As far as the energy phase of the problem is concerned, the operation of two opposing electron beams, i.e., bringing into coincidence the system of center of mass with the laboratory system gives a considerable energy gain for relativistic particles (electrons). Thus, for example, a 100 bev accelerator in its physical effect is equivalent to two opposing electron beams of only ~ 150 mev. An electron accelerator of these energies from the standpoint of dimensions and power, is a relatively modest installation.

The problem of the meeting of two beams can be solved in different ways. For example, Kerst and others[4] considered the possibility of meeting of protons in the case of two adjacent but independently operating ring accelerators. There is however, still another possibility which, it seems to us, opens wide possibilities for the future.

The theory of the ring phasotron, shows that in the characteristic phasotron operation the particles are drawn as it were into the region of higher magnetic fields and we have thereby computed the direct as well as the inverted variant of this accelerator. In the first case, the orbit of the particles represent an unwinding spiral of a very small pitch while for the inverted variant the radius of the orbit decreases slightly as the particle is speeded up.

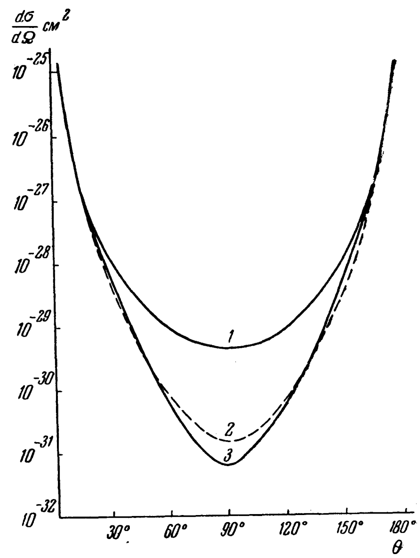

FIG. 1. $1 - r_0 = 0$; $2 - r_0 = e^2 mc^2 = 2{,}8 \cdot 10^{-23}$см, $F(q^2) = (1 + q^2 r_0^2)^{-2}$; $3 -$ same for $F(q) = \exp\left(-{}^1/_2\, q^2 r_0^2\right)$; $\gamma = 200$

If the azimuthal dimensions of the sectors with direct and reversed directions of the magnetic field are made equal. and the sectors themselves are made so that the field intensities in the outer and inner halves are different, then there appears the possibility of combining in one magnetic system the direct and inverted ring of the phasotron. In this case with the sectors arranged with alternating strong and weak fields the electrons may revolve in the straight variant (i.e., inside the ring), for example in the clockwise direction and in the inverted variant (i.e., outside the ring) in the counterclockwise direction, moving in the same operating cycle against each other. The distance between the moving in opposite directions electron beams which began the acceleration process on the inner and outer radii of the electromagnet respectively, will decrease as the energy of the particles increases.

By the introduction of a suitably selected azimuthal asymmetry it is possible, in principle, to bring about the intersection of the trajectories of the electron beams which acquired maximum energy within the limits of a small azimuth. In this manner there is also avoided the first difficulty arising from the need to have available electron beams accelerated up to several tens of bev.

A very important characteristic which determines the feasibility of such an experiment is the effectiveness of computing electron scattering at a given angle considering the fact that the effective cross section of the physical phenomenon under consideration is very small (10^{-29} to 10^{-30} cm^2). Computation shows that with 10^{12} particles in the beam, effective length of the intersection ~ 10 cm, and cross section dimensions of the beams ~ 10 cm^2, the number of counts per unit solid angle for $\sigma = 10^{-29}$ is one count per 10 seconds. A quantity of 10^{12} particles in a beam rotating with the velocity of light is equivalent to ~ 2.5 amps, which is quite permissable from the standpoint of distortion of the accelerator magnetic field by the magnetic field of the beam itself.

The physical equipment for the investigation is envisaged in the form of special coincidence circuits of high resolving power ($\tau = 10^{-8}$ sec), which together with special absorbers which transmit only electrons of maximum energy will enable to make observations in the background of a large number of electrons scattered in the usual manner by the electrons and nuclei of the residual gas atoms in the vacuum chamber. The most dangerous in this respect is the effect of the elastic scattering by nitrogen nuclei, which may result in a high number of chance coincidences thereby considerably distorting the result.

The ratios of false counts, due to the finite resolving time τ of the coincidence circuits, to the number of true counts at 10^{-6} mm pressure in the vacuum chamber, are 3 and 0.1, corresponding to values of angle of 45° and 90 °. Inasmuch as the value of τ varies as the square of the pressure, the experiment can be conducted only in a very high vacuum ~ 10^{-7} mm.

The selected electron energy (150 mev) will make it possible not only to investigate experimentally the variation of the cross section with angle and thereby obtain the answer concerning the size of electrons, but also to traverse a very interesting energy region near the formation thresholds of μ and π mesons.

1 R. Hofstadter and R. W. McAllister, Phys. Rev. **98**, 217 (1955).

2 A. I. Akhiezer and V. B. Berestetskii, *Quantum Electrodynamics*, Moscow, 1953 p. 297

3 Kolomenskii, Petukhov and Rabinovich, Reports (Otchet) Physical Institute, Acad. Sci. USSR, 1953; *Some questions in the theory of cyclic accelerators*, Acad. Sci. Press.

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Translated by J. L. Herson
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Force Fluctuations in an Electron Gas

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FOR the calculation of the microscopic parameters of an electron gas, it is important to known the fluctuation of the random force distribution $w(\mathrm{F})$ which acts on the individual electron. A calculation of w (F) under the assumption that the a priori probability $\tau(\mathrm{r})$ of the particle distribution about an individual particle is a constant, i.e., that there is no correlation in the positions of the particles, was carried out by Holtsmark.[1] In this case a distribution function was obtained such that all its moments diverge, beginning with the second. On the other hand, it is clear that there will be an appreciable correlation only at distances $r_0 \sim e^2 / kT$, at which the mean kinetic energy of the particles is of the order of the value of the potential barrier. For $T \sim 10^5$, the value of r_0 is $\sim 10^{-8}$.

At large distances, there is virtually no correlation, since the gas is assumed to be in a state of statistical equilibrium with constant density. Since the relaxation length and the mean distance between particles are appreciably greater than r_0 under ordinary circumstances, we can neglect the interaction of the surrounding particles located in a sphere of radius r_0. In other words, the motion of the particles in the vicinity of the isolated one is the ordinary Rutherford scattering. The distribution of the particles near the particle under examination can be found by solving the kinetic equation

$$v_i \frac{\partial f}{\partial x_i} - \frac{1}{m} \frac{\partial u}{\partial x_i} \frac{\partial f}{\partial v_i} = 0 \qquad (1)$$

with boundary condition $f(\mathbf{r}, \mathbf{v}) = \exp(-mv^2/kT)$ for $u = 0$, where u (r) is the potential established by the isolated electron. This equation has the integral $f = \Omega(mv^2/2 + u)$ where Ω is an arbitrary function. Consequently, solving this equation, we get

$$\tau(\mathrm{r}) = \exp(-e^2/rkT). \qquad (2)$$

It is of interest to note that in the limiting case of very strong interaction, for which the particles out to the distance $<< r_0$ are in equilibrium with the field of the isolated electron, $\tau(\mathrm{r})$ is obtained in the same fashion.

Making use of the Markov procedure:

$$w(\mathrm{F}) = \frac{1}{8\pi^3} \int \exp(-i\rho\mathrm{F}) A(\rho)\, d\rho,$$
$$A(\rho) = \lim_{N\to\infty} \left[\int \exp(-e^2\rho\mathrm{r}/r^3)\, \tau(\mathrm{r})\, d\mathrm{r}\right]^N,$$

we can show that for large F the function w (F) falls off more rapidly than any power of F. Consequently, the moments of all orders of w (F) must exist. These can be computed by expanding the eigenfunction $A(\rho)$ in a series in powers of ρ. For example,

$$\langle \mathrm{F}^2 \rangle = \int \mathrm{F}^2 w(\mathrm{F})\, d\mathrm{F} = -(\Delta_\rho A(\rho))_{\rho=0} = 4\pi e^2 nkT.$$

In a similar fashion, all the moments of even order can be calculated. [Moments of odd order are equal to zero because of spherical symmetry of w (F).] The value obtained can serve for a rough estimate of the coefficient of viscosity:

$$\mu \sim \sqrt{\langle \mathrm{F}^2 \rangle}/m\bar{v}^2 = \sqrt{4\pi e^2 n/kT}.$$

An exact calculation ought to take into account the correlation of force fluctuations at different points of space, for which it is necessary to compute $\langle \mathrm{F}_i(x)\, \mathrm{F}_k(x') \rangle$. However, the consideration just given shows that the principal contribution to the viscosity, the diameter, the relaxation length for particles with long range interaction will not be given by an account of well regulated, averaged forces (pair collisions, interaction with vibrations) since this contribution is proportional to the first moment of w (F) and the interaction with the fluctuations of the electric field. For these quantities, a consideration of the fluctuation scattering is more important than consideration of the well regulated deceleration.

1 J. Holtsmark, Ann. Physik 58, 577 (1919); Phys. Z. 20, 162 (1919); 25, 73 (1924).

Translated by R. T. Beyer
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Other Errata

Page	Column	Line	Reads	Should Read
Volume 4				
38	1	Eq. (3)	$\ldots\frac{\pi r^2\rho^2\rho^2{}_n}{\rho_s^2},$	$\ldots\frac{\pi r^2\rho^2\rho_n}{\rho_s^2},$
196		Date of submittal	May 7, 1956	May 7, 1955
377	1	Caption for Fig. 1	$\delta_{35}=\eta-21\cdot\eta^5$	$\delta_{35}=-21^\circ\eta^5.$
377	2	Caption for Fig. 2	$\alpha_3=6.3^\circ\ \eta$	$\alpha_3=-6.3^\circ\eta$
516	1	Eq. (29)	$s^2/c^2\ldots$	s/c
516	2	Eqs. (31) and (32)	Replace A_1s^2/c^2 by A_1	
497		Date of submittal	July 26, 1956	July 26, 1955
900	1	Eq. (7)	$\ldots\frac{i}{4\pi}\sum_{c,\alpha}\frac{\partial w_a(t,P)}{\partial P^\alpha}\ldots$	$\ldots 2\pi^2 i\sum_{c,\alpha}\ldots$
			(This causes a corresponding change in the numerical coefficients in the expressions that result from the calculation of the effects of the plasma particles on each other).	
804	2	Eq. (1)	$\ldots\exp\{-(\overline{T}-V')\}$	$\ldots\exp\{-(\overline{T}-V')\tau^{-1}\}$
Volume 5				
59	1	Eq. (6)	$v_l(1\partial F_0/\partial x)+\ldots$ where E_l is the projection of the electric field E on the direction 1	$\overline{(v\partial F_0/\partial x)}+\ldots$ where the bar indicates averaging over the angle θ and E_l is the projection of the electric field E along the direction 1
91	2	Eq. (26)	$\Lambda=0.84\,(1+22/A)$	$\Lambda=0.84/(1+22/A)$
253		First line of summary	$Tl^{204,\ 206}$	$Tl^{203,\ 205}$
318	1	Figure caption	$\ldots e^2mc^2=2.8\cdot10^{-23}$ cm,	$\ldots e^2/mc^2=2.8\cdot10^{-13}$ cm,
398		Figure caption	... to a cubic relation. A series of points etc.	... to a cubic relation, and in the region 10 – 20°K to a quadratic relation. A series of points ●, coinciding with points O, have been omitted in the region above 10°K.