From the difference between λ_A and λ_c therefore one can readily calculate the relative difference in the masses m^+ and m^- of positive and negative electrons. If our observed discrepancy is to be so interpreted in its entirety then

$$(m^- - m^+)/m^- = 2(\lambda_A - \lambda_c)/\lambda_A = 0.82\times 10^{-4}. \quad (5)$$

The probable error to be assigned to this number we believe lies somewhere between an estimated upper "limit of error" of $\pm 0.82\times 10^{-4}$ and a probable error by internal consistency of the individual measurements themselves of $\pm 0.1\times 10^{-4}$. The direction of the discrepancy is consistent with a heavier mass for negative than for positive electrons.

We wish to emphasize that the evidence for this discrepancy $(\lambda_A - \lambda_c)$, *depends entirely on the possibility of calibrating the 2-meter curved crystal gamma-ray spectrometer with high absolute accuracy by means of x-rays.* Other nuclear physics laboratories equipped with β-ray spectrometers may (and we hope will) attempt to verify with all the precision available the *ratios* of the energies of the various lines we have recently measured such as Au^{198}, Cu^{64}, Co^{60}, Ta^{182}, and since our measurements on some of these such as Au^{198} are at present somewhat more accurate than our work to date on Cu^{64} it may be possible in this way to improve our knowledge of λ_A *but the absolute value of* λ_A for comparison with λ_c must at present *rest on the calibration of our instrument alone.*

We plan in the near future to repeat the measurements of λ_A with higher accuracy. Recent very considerable improvements in the sensitivity of our instrument through the use of a crystal scintillation counter and an improved collimator will, we hope, make possible a considerable improvement in resolving power. We plan also to study the effect of changing the atomic number of the substance in which the annihilation takes place. Plans are also under way for a direct precision comparison of the charge-to-mass ratios e/m^+ and e/m^- by a new method involving the new homogeneous field axial focusing β-ray spectrometer[8] whose construction at this Institute is now nearing completion.

* Assisted by the joint program of the ONR and AEC.

[1] I am indebted to W. K. H. Panofsky for pointing out to me the importance of this question.
[2] DuMond, Lind, and Watson, Phys. Rev. 75, 1226 (1949).
[3] J. W. M. DuMond and E. R. Cohen, Revs. Modern Phys. 20, 82 (1948).
[4] The shift because of the potential energies of the recombining pair members has only been estimated roughly. For this reason, our program includes study of the annihilation radiation in substances of different atomic numbers.
[5] De Benedetti, Cowan, and Konneker, Phys. Rev. 76, 440 (1949).
[6] J. W. M. DuMond, Phys. Rev. 75, 1226 (1949).
[7] Lind, West, and DuMond, Phys. Rev. 77, 475 (1950).
[8] No description of the design of this new instrument has, as yet, been published. Its design exploits the ideas of the author for obtaining optimum luminosity and energy resolution set forth in a recent paper in Rev. Sci. Instr. 20, 160 (1949).

The Half-Life of Na^{24}

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BEING concerned with the development of precise methods of measuring half-lives, we have used Na^{24} as one of the isotopes for checking our approach to the problem. We have obtained a value of 15.060 ± 0.039 hr. This is in accord with the result, 15.04 ± 0.04 hr reported by Solomon.[1] Wilson and Bishop[2] have reported a value of 14.90 ± 0.02 hr, which is at variance with our determination. It appears that an error in their analysis is responsible for the discrepancy. They indicated correctly that the points on the semilogarithmic plot of the activity *versus* time as obtained in their experiment must be weighted according to the square of the measured activity. For a decaying activity the weighting factors thus decrease with time. Instead of analyzing the decay directly, they compare the activity of the Na^{24} source with that of a relatively long-lived source by considering the ratio of the activities. The ratio that they formed inadvertently was that of the long-lived activity to the Na^{24} activity. This function increases with time and thus cannot properly be considered the "activity" as far as the application of the weighting factors in their analytical treatment is concerned. Using their published data we have recalculated the runs, taking as the activity function to be analyzed the ratio $u = (Na^{24}\text{ activity})/(\text{reference activity})$.

With t the elapsed time in hours, the resulting linear logarithmic equations are:

Series I	$\log u = -1.32143 - 0.04576t$
Series II	$\log u = -0.89174 - 0.04667t$
Series III	$\log u = -1.27935 - 0.04590t$

giving, respectively, a half-life of:

15.150 ± 0.070 hr, 14.852 ± 0.041 hr and 15.102 ± 0.076 hr.

The average half-life is thus 14.96 ± 0.10 hr which falls within the range of our measurement. It should be noted that the error in measurement due to statistical variation of the reference activity was considered to be negligible.

The interest and encouragement of Dr. F. N. D. Kurie in this work is gratefully acknowledged, and the verification of our calculations by Dr. G. R. Bishop[3] is appreciated.

[1] A. K. Solomon, Phys. Rev. 79, 403 (1950).
[2] R. Wilson and G. R. Bishop, Proc. Phys. Soc. London A62, 457 (1949)
[3] G. R. Bishop (private communication, November 20, 1950).

Choice of Gauge in London's Approach to the Theory of Superconductivity

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IT has been pointed out by London[1] that it is possible to derive the phenomenological equation of superconductivity:

$$\mathrm{curl}(\Lambda \mathbf{j}) = \mathbf{B}, \quad (1)$$

from quantum theory if it is assumed that the superconducting state is such that the wave function, Ψ, of the conduction electrons is not altered very much by the magnetic field. The expression for Ψ depends on the choice of gauge in the vector potential, $\mathbf{A}$. London assumes that Ψ is approximately equal to the wave function for zero field, Ψ_0, if the gauge is chosen in such a way that

$$\mathrm{div}\mathbf{A}_s = 0;\quad \mathbf{A}_{s\perp} = 0 \text{ on surface.} \quad (2)$$

The subscript s will indicate this particular choice. For a simply connected region, these conditions determine the gauge uniquely.[2] The current density, $\mathbf{j}$, is then proportional to $\mathbf{A}_s$;

$$\mathbf{j} = \mathbf{A}_s/\Lambda, \quad (3)$$

and the curl of this relation gives (1). While this procedure is reasonable, it seems desirable to derive (2) from a gauge invariant formulation of the theory.

Let $\mathbf{A}$ be the vector potential for arbitrary choice of gauge. Terms in the Hamiltonian which involve the magnetic field are

$$H_m = (1/2m)\sum_{\alpha=1}^{n}\{[\mathbf{p}_\alpha + e\mathbf{A}(\mathbf{r}_\alpha)/c]^2 - p_\alpha{}^2\}, \quad (4)$$

where $-e$ is the charge on an electron and the sum is over all electrons. Let us consider the class of wave functions of the form

$$\Psi = \exp[(ie/\hbar c)\Sigma_\alpha \varphi(\mathbf{r}_\alpha)]\Psi_0(\mathbf{r}_1\cdots\mathbf{r}_n). \quad (5)$$

The exponential factor is of the type which is introduced when a gauge transformation

$$\mathbf{A}\rightarrow\mathbf{A}+\mathrm{grad}\,\varphi$$

is made, and is required when the gauge is chosen arbitrarily. We shall choose φ in such a way as to make the first-order energy,