refer, that have a direct bearing on quanta (that is, discontinuity). In my theory they give me the quantal part of the unification; in Schrödinger's, nothing, because they are in no way unusual.

A requirement in all electromagnetic problems is the proper statement of boundary conditions. So it is in respect of the energy of uncertainty. Once the boundary conditions are specified, the energy quanta become determinate. The boundary conditions for the quantal part of the problem and for the electromagnetic part are, not unnaturally, found to be the same in my analysis. This is where indeterminate theory links the indeterminism of electromagnetic potentials with the uncertainty principle of Heisenburg.

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[1] *Nature*, 153, 572 (1944).
[2] Eddington, Sir A. S., Univ. Nacional d.S. Marcos. Lima, Ano XLVI, 447.
[3] *Nature*, 154, 94 (1944).

Isomorphic Relationship between Rubidium and Thallium in Igneous Minerals

V. M. GOLDSCHMIDT[1] has been able to demonstrate that the radius of an ion is a fundamental factor in regulating isomorphic behaviour, ions of like size being capable of replacing each other isomorphically within a crystal lattice. The application of this law of crystal chemistry to a study of the distribution of the elements in the earth's crust has yielded fruitful results; in particular, the behaviour of many of the rarer elements during the fractional crystallization of a magma is now reasonably well understood. For example, Goldschmidt[2] has pointed out that, since the radii of Rb^+, Tl^+ and Cs^+ (1·49, 1·49 and 1·65 A., respectively) are similar to that of K^+ (1·33 A.), these elements are commonly found in potassium-rich minerals, particularly those of late pegmatitic phases.

As a result of the identity of the radii of Rb^+ and Tl^+, it was decided to investigate whether these two elements were quantitatively associated in igneous minerals, that is, capable of entering crystals of various types with the same facility. In all, seventy-two analyses of lepidolite (the richest mineral in both rubidium and thallium), zinnwaldite, amazonite, potash feldspars other than amazonite, phlogopite, muscovite and pollucite, have been carried out, and the analyses reveal a very close relationship between rubidium and thallium, the maximum variation of the ratio Rb_2O/Tl_2O being 35–450, that is, $10 \times 1{\cdot}3$, with an average ratio of 135. The concentration range covered in these analyses is about a thousand, and throughout there is no apparent change in the ratio, the only apparent factor influencing the ratio being the relative initial paucity or richness of either element in a particular source.

Graphically, a plot of log per cent Rb_2O v. log per cent Tl_2O reveals that a straight line of unit slope accommodates these points most satisfactorily, that is, Rb^+ and Tl^+ enter crystal lattices and replace K^+, and in the case of pollucite Cs^+, with exactly the same facility. In contrast, analytical data on rubidium and cæsium show that although these two elements are invariably associated, the ratio Rb_2O/Cs_2O is very variable and tends to decrease with differentiation as a consequence of the larger radius of the cæsium ion.

Direct evidence of the analogous isomorphic behaviour of Rb^+ and Tl^+ has been furnished by the analyses of more than one mineral from the same pegmatite, the ratio Rb_2O/Tl_2O remaining exactly constant.

This identity in the isomorphic behaviour of Rb^+ and Tl^+ during differentiation furnishes a striking and elegant example of the manner in which ionic size determines isomorphic behaviour and thus assists in regulating the distribution of the rarer elements.

All the analyses embodied in the above investigation were carried out spectrographically.

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[1] Goldschmidt, V. M., *J. Chem. Soc.*, 655 (1937).
[2] Goldschmidt, V. M., *Trans. Farad. Soc.*, 25, 253 (1929).

Distribution of Wars in Time

A STATISTICAL regularity in the dates of wars has been brought to notice by the following numerical process. A list was prepared of wars in the world as a whole. Each calendar year was thereby characterized by the number, $x = 0, 1, 2, 3, 4, \ldots$, of wars which began in it. Next, the number, y, of years which had each such character was counted. A similar procedure was applied to the beginnings of peace. Here are some results:

	x	=	0	1	2	3	4	>4
War,	y	=	63	35	9	2	1	0
Peace,	y	=	62	34	13	1	0	0
$110\, e^{-\mu}\mu^x/x!$		=	62·0	35·5	10·2	1·9	0·3	0·0

where $\mu = 63/110$. The formula is the Poisson law of improbable events. Other phenomena, known to be described by the Poisson law, include the distribution in time of the alpha particles emitted from radioactive substances[1], or of deaths by kick from a horse[2].

This impersonal account of the beginnings of war and of peace contrasts with the personal details in the newspapers and history books. In somewhat the same manner the statistics of marriage contrast with a love-story in a biography. The Poisson law is statistical in the sense that it does not predict the date of any future peace or war.

The particular set of wars summarized in the above table are fatal quarrels, which caused from $10^{3\cdot5}$ to $10^{4\cdot5}$ deaths, and which ended from A.D. 1820 to 1929 inclusive[3]. But the Poisson law, with other constants, also describes the beginnings of wars from A.D. 1500 to 1931, as set out in Prof. Quincy Wright's list[4].

A more critical account of these regularities has been accepted for publication by the Royal Statistical Society.

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[1] Rutherford, Chadwick and Ellis, "Radiations from Radioactive Substances" (Camb. Univ. Press, 1930), 172.
[2] Bortkewitsch, quoted by Pearson, K., "Tables for Statisticians", (Cambridge University Press, 1914), lxxvii.
[3] *Nature*, 148, 598 (1941).
[4] Wright, Q., "A Study of War" (University of Chicago Press, 1942), appendix xx.