this description, to an analogous variety of currents in the superconductor. It could be shown that this description provides just as many possible currents as are required in order to satisfy uniquely the macroscopic boundary conditions for current and field. All currents observed in the conductivity experiments can be conceived as produced by the magnetic field. The new relation between current J and magnetic field H derived on this basis is

$$\text{rot}\,\Lambda J = -H,$$

where Λ is a constant characteristic of the superconductor.

This mechanism of conduction is entirely different from that discussed in customary theories of conductivity: The transport of electricity is not based, as usually, on *progressive* waves (or wave packets) but on *stationary* waves. By these a transport of electricity can only be effected *in the presence of a magnetic field* and just this is our assertion as to the nature of the supercurrents.

Though in such a way a serious difficulty could be removed which seemed hitherto to render impossible any theory of superconductivity, the problem remained yet unsolved as to *which kind of interaction* could be made responsible for the appearance of such separated diamagnetic states.

In a paper just published by Slater[3] attention has been drawn to a mechanism which seems to be able to explain the appearance of such a separation of the lowest Bloch eigenvalues as characterized by (1) and it is therefore of interest to examine whether this mechanism is able to fill up the gap still left in the theory of superconductivity. Actually, Slater seems not to have thought of the particular possibility, mentioned above, of a magnetic interpretation of the phenomena of conductivity. In any case, he did not undertake to make plausible a property like that formulated under (2). Instead he refers rather to the notorious difficulties in dealing with the resistance problem at low temperatures. It appears doubtful, indeed, whether such a proof of the superconductivity of the model can be given. Moreover, proof of an infinitely high conductivity would not imply the fact that a superconductor, when formed in a magnetic field, has a magnetic induction zero. The reference in Slater's paper to the parallelism between specific heat and resistance seems to be rather misleading: there are superconductors with a high specific heat in the normal phase and nevertheless a high critical temperature (e.g., *Ta* has a high specific heat and a critical temperature of 4.4°).

The construction of such isolated states is certainly of greatest interest, and perhaps the indications given here may be found useful for discussing this or similar models.

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March 7, 1937.

[1] F. and H. London, Proc. Roy. Soc. **A149**, 71 (1935); Physica **2**, 341 (1935). M. v. Laue, F. and H. London, Zeits f. Physik **96**, 539 (1935). F. London, Proc. Roy. Soc. **A152**, 25 (1935). E. Schrödinger, Nature **137**, 824 (1936). H. London, Proc. Roy. Soc. **A152**, 650 (1935); **155**, 102 (1936). F. London, Physica **3**, 450 (1936). Nature **137**, 991 (1936). For a general review see F. London, *Une conception nouvelle de la supraconductibilité*. Actualités scientifiques et Industrielles No. **458** Paris (Hermann & Cie) 1937.

[2] See e.g., Proc. Roy. Soc. **A152**, 31–33 (1935).

[3] J. C. Slater, Phys. Rev. **51**, 195 (1937).

On the Probability of Detecting Nebulae Which Act as Gravitational Lenses

Recently various authors[1, 2] have again[3] considered the possibility of observing the image of a distant star A whose light is bent around some nearer star B. For reasons discussed by these authors, the probability that the mentioned effect will ever be observed with *stars* is vanishingly small. The general feeling therefore was that the idea of gravitational lenses affords "perfect tests of general relativity that are unavailable," as Professor H. N. Russell[2] puts it.

The problem in question, however, takes on a radically different aspect, if, instead of in terms of stars we think in terms of *extragalactic nebulae*.[4] Provided that our present estimates[5] of the masses of *cluster nebulae* are correct, the probability that nebulae which act as gravitational lenses will be found becomes practically a *certainty*. The reasoning which leads to this optimistic view is as follows.

Let us consider only the least probable but perhaps most spectacular case in which the straight line which joins the observer in O with the gravitational center of the lens-nebula B passes through a distant nebula A. What is the probability that for a specified nebula B this "coincidence condition" is satisfied? Clearly, if all of the distant nebulae whose apparent magnitude is brighter than m cover a total solid angle ω_m, the probability p for OB to intersect one of these nebulae is $p=\omega_m/4\pi$. Consequently, among $n=1/p$ nearby nebulae B, one satisfies on the average the coincidence condition.

On limiting exposures with the 100-inch telescope about 1/400 of the photographic plate is on the average covered by nebular images. Thus for a limiting magnitude of about $m=21.5$ we have approximately $n=400$. With gravitational focusing, nebulae considerably fainter than $m=21.5$ will be observable. Thus around one in about one hundred nebulae B the ring-like image of a distant nebula should be expected, *provided* that the chosen nebula B has an apparent angular radius ρ smaller than the angles γ through which light is deflected on grazing the surface of this nebula. Present estimates of masses and diameters of cluster nebulae are such that the observability of gravitational lens effects among the nebulae would seem insured. In any case, whatever the outcome, the search for such effects will provide us with valuable information regarding the masses of nebulae.

In searching through actual photographs, a number of nebular objects arouse our suspicion. It will, however, be necessary to investigate certain composite objects spectroscopically, since differences in the red shift of the different components of such objects will immediately betray the presence of gravitational lens effects. Until such tests have been made, further discussion of the problem in question may be postponed.

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Pasadena, California,
March 18, 1937.

[1] A. Einstein, Science **84**, 506 (1936).

[2] H. N. Russell, Scientific American, p. 76, Feb. (1937).

[3] Dr. G. Strömberg of the Mt. Wilson Observatory kindly informs me that the idea of stars as gravitational lenses is really an old one. Among others, E. B. Frost, late director of the Yerkes Observatory, as early as 1923 outlined a program for the search of such lens effects among *stars*.

[4] F. Zwicky, Phys. Rev. **51**, 290 (1937).

[5] F. Zwicky, Helv. Phys. Acta **6** 124 (1933).