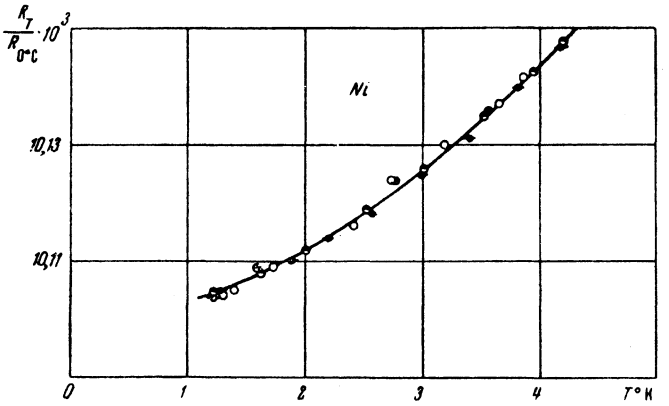

FIG. 2

of iron and nickel, which distinguishes them from other metals and which manifests itself in the presence of a linear term in the temperature dependence of the resistance.

It is interesting to note that the reults of the present research agree with the conclusions obtained in one of the works of Turov.[1]

[1]E. A. Turov, Izv. Akad. Nauk SSSR, Ser. Fiz. 19, 474(1955).

Translated by R. T. Beyer
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The Crystalline Structure of Hydrogen and Deuterium

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THE structure of solid hydrogen has been investigated by Keesom and his co-workers[1], who found it to possess a hexagonal close-packed lattice with parameter $a = 3.75$ A. The structure of deuterium was not studied, and it was to determnne this that the present work was undertaken. Specimens of solid deuterium were obtained by condensation of the gas onto a copper capillary filled with liquid helium. Use of the strong-focus method of x-ray crystallography made it possible to obtain x-ray patterns with sharp lines for deuterium with exposures of one to two hours. Unfortunately, as a result of the rapid decrease of the atomic form factor with angle, the deuterium lines were visible only at small angles; this made it difficult to obtain reliable measurements from the x-ray patterns or to determine accurately the parameters of the lattice. With as much confidence as these x-ray patterns seemed to warrant, we determined the structure of deuterium to be tetragonal, with a ratio of axes $c/a = 0.94$ and a paramter $a = 5.4$ A. This leads to a density of 0.18 gm/cm^2 for deuterium, which differs by only 10% from the value obtained by direct measurement (2). In view of these results, it appeared advisable to review the data on the structure of hydrogen, for it seemed surprising that the two isotopes should crystallize into lattices having different symmetry. In particular, such a difference might arise from the occurrence of polymorphism in the two isotopes, with transition points in the vicinity of 4.2° K, so that at this temperature they might be found in different phases. However, x-ray patterns for deuterium and hydrogen obtained at lower temperatures failed to confirm this supposition--neither hydrogen nor deuterium alters its structure in the temperature range from 1.5° to 4.1°K.

In the paper by Keesom, *et al.*,[1] the x-ray patterns themselves are not shown; it appears, however, that they consisted of discrete reflections, through which Debye curves were drawn. A direct computation of the line width to be expected from the conditions prevailing in the experiment shows this width to exceed the separation of certain of the more closely-spaced lines; i.e., the reflections which these authors have assigned to different lines could actually belong to a single line. This is the probable explanation for the fact that the five intense lines in the x-ray patterns obtained by Keesom, *et al.*, correspond to three lines in our patterns. Moreover, certain lines are erroneously ascribed by Keesom, *et al.*, to the β-spectrum. An exposure made through a filter passing only the

β-radiation showed that all of the intense lines belong to the interference system of the $K\alpha$-radiation. Thus, the data on the structure of hydrogen obtained at the Leiden laboratory, and incorporated into all of the reference literature, are evidently incorrect. With the aid of the Hull-Davey curves, we found that the hydrogen patterns could be equally well interpreted as arising from a tetragonal lattice. That the lattices of hydrogen and deuterium correspond to crystals of non-cubic syngony receives confirmation from our observation that they both possess the property of double refraction. This does not support the older data, according to which solid hydrogen is optically isotropic.[3]

[1]Keesom, DeSmedt, and Mooy, Leid. Comm. 209d (1930).

[2]H. D. Megaw, Phil. Mag. 28, 129 (1939).

[3]W. Wahl, Proc. Roy. Soc. (London) A88, 61 (1913).

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An Experimental Manifestation of Instability Of the Normal Phase in Superconductors

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IN the experiments of Faber,[1] considerable supercooling of the normal phase of Al has been achieved near the critical temperature T_c. The magnetic field H_s at which the transition into the superconducting state takes place is approximately the same for various samples and has a mean value $H_s \sim 0.05\, H_{cm}$, where H_{cm} is the equilibrium critical field for the bulk metal. Values of $H_s \sim (0.035 - 0.04) H_{cm}$ were also observed (cf. Fig. 3 of Ref. 1). This gives rise to the impression that the limiting supercooling is a characteristic of the ideal metal, which cannot be supercooled to values of the field below some value H_{c1}, and that for Al $H_{c1} \sim (0.035 - 0.04)\, H_{cm}$.

We would like to call attention to the fact that this result follows directly from the theory of superconductivity developed in Ref. 2. Actually, it is shown in Ref. 2 that under certain conditions the normal phase of a superconductor becomes unstable with regard to the formation of lamina (nuclei) of the superconducting phase. In particular, these lamina of the superconducting phase are formed when the normal phase is in a magnetic field fulfilling the condition*

$$H = \varkappa H_{cm} / \sqrt{2}\,(n + 1/2), \qquad n = 0, 1, 2, 3, \ldots, \quad (1)$$

$$\varkappa = (\sqrt{2}e/\hbar c)\, H_{cm} \delta_0^2 = 2{,}16 \cdot 10^7 H_{cm} \delta_0^2,$$

where δ_0 is the penetration depth for the superconductor in a weak magnetic field. From Eq. (1) it follows that the magnetic field within the normal phase can be reduced only as far as the value

$$H_{c1} = \sqrt{2}\varkappa H_{cm}, \qquad (2)$$

which is obtained from (1) for $n = 0$. In fields $H > H_{c1}$ —the formation of nuclei of the superconducting phase is associated with the appearance of a surface energy; the normal phase is therefore metastable over the range $H_{c1} < H < H_{cm}$ If, however, $H = H_{c1}$, the normal phase is unstable, and the superconducting transition must take place.** For Al near T_c, $\varkappa = 0.025$[(cf. Ref. 3, in which are given the values*** $\varkappa_0 = 2\varkappa$, $(T_c) = 0.050$)]. Hence, in accordance with (2), $H_{c1} = 0.0354\, H_{cm}$, which is in excellent agreement with the experimental value cited above. We note that for Al the theory is also in complete accordance[3] with experiment[1] with regard to the magnitude of the surface energy, as determined by this same parameter $\varkappa$. For Sn the limiting value H_{c1} is not reached. This circumstance may be connected with the fact that the case of an anisotropic metal is in general more complex. It is more probable, however, that in this case the reason is the same as that applying to Al for $T < 0.9\, T_c$, where superconductivity arises for field $H_s > H_{c1}$. In the region $T > 0.9 T_c$, however, as is shown in Ref. 1, the formation of nuclei is impeded by the fact that the characteristic length Δ exceeds the distance between the lattice "defects", which serve as nucleation centers. For Sn near T_c the length Δ is on the order of four times smaller than for Al, as a consequence of which the formation of nuclei is easier.

For metals having small values of $\varkappa$ the instability of the normal phase can be manifested only through supercooling. On the other hand, as is noted in Refs. 2 and 7 and is clear from (2), for $\varkappa > \varkappa_c = 1/\sqrt{2}$ instability of the normal phase occurs even for $H = H_{c1} \geq H_{cm}$; superconductors for which