neutron*, the kinetic energy of the α-particles and the neutrons and the upper limit of the spectrum of the emitted positive electrons.

A second way of deciding the question would be to observe the recoil of the nucleus in β-decay. With natural β-rays this is in practice impossible because the recoil energy is too small, but the nuclei involved in artificial β-decay are much lighter. The kinetic energy of recoil of a disintegrating N^{13} nucleus would be of the order of some hundreds of volts if there were no neutrinos. If the neutrino hypothesis is correct, there would be a defect of momentum which would be uniquely connected with the lack of observable energy in each individual process.

In addition to the nuclear processes mentioned in our previous communication, it may also be expected that a nucleus catches one of its orbital electrons, decreases by one in atomic number, and emits a neutrino. (A corresponding process with increase in atomic number is not possible because of the absence of positive electrons.) This process further limits the possible mass differences between stable neighbouring isobares, and particularly between neutron and proton. If the hydrogen atom is to be stable, we must have (for the masses):

Proton + electron < neutron + neutrino.

The probability of such a process is less than that of a process involving emission only, the energy of the neutrino being the same. The reason is that the momentum of the electron, which enters in the third power, is about a hundred times smaller. But even for a surplus energy of 10^5 volts, the life-period of hydrogen would be only 10^{10} years, which seems incompatible with experimental facts. If therefore the neutrino is not heavier than the electron, the neutron must be at least as heavy as the proton.

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* The accuracy with which the mass of the neutron can be determined at present is, however, far from being sufficient for this purpose.

[1] H. Bethe and R. Peierls, NATURE, 133, 532, April 7, 1934.

Optical Constants of Alkali Metals

A NUMBER of recent researches[1] have shown that electrons in some metals—in the first place in alkali metals—can be considered with sufficient approximation as free. The transparency of alkali metals in the ultra-violet region discovered by Wood[2] has been recently explained by Zener[3] from the point of view of free electrons. Immediately after the publication of Zener's communication, we calculated the optical constants n and k of the alkali metals, using the free electron gas model and taking into account the collisions of the electrons with the atomic lattice, and we obtained satisfactory agreement with the measured values.

Kronig in a recent letter[4] states that the calculation of the optical constants of alkali metals can be carried out with the help of the formulæ of his dispersion theory in metallic conductors if one takes into consideration only the free electrons. In connexion with this, it is interesting to note that our calculations based on the simple Sommerfeld theory of metals give the same results, as can be inferred from the comparison of our results with the numerical values published by Kronig. Our calculations have been made taking into account (1) the motion of free electrons under the influence of the variable external field, (2) the collisions which stop this motion. The average velocity of electrons was calculated in just the same way as in the Lorentz theory of the collision damping. With this average velocity the current is obtained, which is substituted in Maxwell's equations. The complex dielectric constant is given by the final formula

$$\varepsilon = 1 - \frac{\omega_0^2}{\omega^2}\frac{(\omega\tau)^2}{1+(\omega\tau)^2} - i\frac{\omega_0^2}{\omega^2}\frac{\omega\tau}{1+(\omega\tau)^2},$$

where $\omega_0^2 = 4\pi Ne^2/m$ and τ is the time between two successive collisions of the free electron with the lattice calculated according to the Sommerfeld formula from the specific conductivity. The formula contains two parameters which are determined by non-optical measurements: (1) the specific conductivity, σ; (2) the number of electrons, N, per

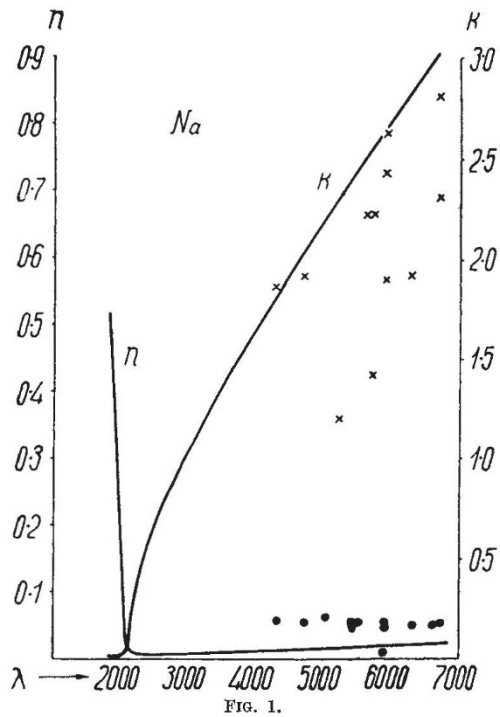

FIG. 1.

cm.^{3}. Putting $\varepsilon = (n - ik)^2$ we obtain n and k represented for the case of sodium by the curves in Fig. 1. Dots and crosses denote the measured values[5] n and k.

The scattering of experimental values is very large, which is explained by the low accuracy of measurements, due to the difficulty of preparing a clean metallic surface. For potassium the agreement with regard to n in the region of small values is somewhat worse, but the order of magnitude remains the same. The values of k in this case came out better than for sodium. When $\omega\tau < 1$, our formulæ go over into the classical expressions of Drude.

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[1] O'Bryan and Skinner, *Phys. Rev.*, **44**, 602; 1933.
[2] Wood, *Phys. Rev.*, **44**, 353; 1933.
[3] Zener, NATURE, **132**, 968, Dec. 23, 1933.
[4] Kronig, NATURE, **133**, 211, Feb. 10, 1934.
[5] Landolt-Börnstein, "Phys. Chem. Tab."