on a large scale, they are now found unmistakably to exist.

Table I gives the values of the photoelectric work functions in electron-volts as determined by the old and new methods. Fig. 1 gives an example of how closely the observations fit the theoretical curve.

While no accurate record of the temperature was made for all of the observations, its value was always very close to 298°K in the neighborhood of the photoelectric cell, and this value has been used in all calculations. A possible error of one or two degrees will not invalidate the results. The anomalous shift in germanium is unexplained. For calcium the range of frequencies is probably too great to cover the assumptions of the theory. It is possible that the range is sufficient such that appreciable changes occur in the reflecting power of the surface.

George B. Welch

Cornell University,
Ithaca, N. Y.,
April 11, 1932.

Absolute X-ray Wave-lengths

In a recent issue of this Journal Bäcklin[1] has attempted to criticise the writer's results[2] on "x-ray wave-lengths by dispersion" by failing to quote correctly the writer's statements. He says "The conclusions drawn from the results are: (1) 'There is now very little question about the real value of e/m, and (2) The grating measurements of x-ray wave-lengths are definitely in error'." Reference to the writer's paper will show that in both quotations important qualifying words have been omitted. In order to indicate clearly the present status of the wave-length problem I shall comment briefly on Bäcklin's letter and then add some new considerations which further support the writer's view that the grating wave-lengths are in error.

Eq. (9), page 3 of the paper in question[2] may be written

$$\lambda^2 = K\cdot\delta\cdot(e/m)^{-1}$$

where K is a factor depending on the properties of the refracting material and is practically insensible to small changes in λ (0.5 percent). Since δ is the only quantity measured by refraction it is obvious that both λ and e/m cannot be determined from this one relation. Bäcklin's implication that this was attempted by the writer is absurd. A mere calculation from Eq. (9) would have shown him that this was not true. The value of e/m substituted in Eq. (9) was

$$e/m = 1.761 \times 10^7 \text{ e.m.u.}$$

It is generally agreed that the value of e/m cannot be larger than this value and according to the most recent determination it is probably less. The use of a smaller value would of course increase λ slightly but would not destroy the agreement between crystal λ and the dispersion λ.

Bäcklin calls attention to the fact that the "exceedingly careful, systematic investigation by Larsson,[3] using several methods for determining δ" is in error by 0.5 percent. According to Larsson's Inaug. Diss. 1929 only one method was used for determining the refraction by quartz. The density of the quartz prism was "precisely" measured as

$$\rho = 2.6685$$

As the accepted value is $\rho=2.649$ the writer contemplated arbitrarily changing Larsson's value when his results were considered, but in view of the simplicity of density measurements I finally concluded that he must have used an exceptional piece of quartz. Siegbahn's "Spektroskopie der Röntgenstrahlen" 1931 uses $\rho=2.65$ which is 0.7 percent lower than that given by Larsson while Bäcklin corrects Larsson's results by 0.5 percent. Thus there are three values of the density which have been issued from the same laboratory, namely

$$\rho = 2.6685$$
$$\rho = 2.6552$$
$$\rho = 2.65.$$

Recent refraction measurements[4] of x-rays by calcite have shown that when λ is obtained from Eq. (9) one again finds wave-lengths either $\leqq$ the crystal values. While the precision of these experiments is much less than that obtained with quartz, it is interesting (while not very significant) that all λ's are

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[1] E. Bäcklin, Phys. Rev. **40**, 112 (1932).

[2] J. A. Bearden, Phys. Rev. 39, 1 (1932) and **38**, 835 (1931).

[3] A. Larsson, Inaug. Diss., Uppsala (1929).

[4] J. A. Bearden, and C. H. Shaw, Wash. Meeting of the Am. Phys. Soc. (1932).

either $\leqq$ the crystal λ. Larsson[3] has made two determinations of δ for the Cu $K\alpha_1$ line refracted by calcite but since his results differed from each other by more than 3 percent there is no point in calculating λ from them.

It should be emphasized that the calculation of λ assumes the validity of the quantum theory of dispersion. A precise determination of δ is thus the important experimental fact which, if λ were known, could be used to accurately test the theory. But since the real value of λ is probably more in doubt than the theory it is plausible to assume the theory and calculate λ.

In making a decision between accepting either crystal or grating wave-lengths the following facts should be considered:

1. Allison[5] has recently examined samples of calcite in which there is no evidence for mosaic structure from intensity of reflection measurements. Thus, the calculated grating constant should be correct.
2. The agreement between the value of h as determined by x-rays[6] agrees well with the best values obtained by other methods.
3. The inconsistency[7] of the fundamental constants when the grating wave-lengths are adopted as absolute values.
4. The dispersion of x-rays.

Thus there are strong indications that the grating wave-lengths are in error. It should be pointed out, however, that a change of as much as 0.1 percent could be made in the crystal grating constant without conflicting with any of the above results.

J. A. Bearden

Johns Hopkins University,
April 16, 1932.

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[5] S. K. Allison, Wash. Meeting of the Am. Phys. Soc. (1932).

[6] W. Duane, Palmer, and Chi-Sun Yeh, Proc. Nat. Acad. Sci. **7**, 237 (1931); H. Feder, Ann. d. Physik (5) **I**, 494 (1929).

[7] R. T. Birge, Phys. Rev. April 15 (1932).

Accommodation Coefficients of Helium and Argon against Tungsten

Zener[1] has recently calculated the quantum mechanical theory of the exchange of energy between monatomic gases and solid surfaces. He assumes a repulsive potential curve of the form $V=Ce^{-r/d}$, so that the repulsive energy to $1/e$ of its value at $r=d$. In order to make an experimental test of this theory, it seemed worth while to determine the relative accommodation coefficients for two of the noble gases under conditions of cleanliness of surface and gases comparable to those used by Roberts.[2,3]

This determination has been made for argon and helium. The gases were purified by circulation over a hollow cathode misch-metal bottle, hot copper and copper oxide and a hot tungsten filament (in addition to a chabazite trap at liquid air temperature, in the case of the helium). The accommodation coefficient was determined by measuring the heat loss from a two mil tungsten filament, 35.6 cm long, in a water-cooled Pyrex tube. The temperature difference between the wire and the walls, which was of the order of ten degrees, was determined by a resistance measurement in the usual way. The filament was cleaned by heating to about 2000°K.

The values obtained for the accommodation coefficients before cleaning the wire were 1.00 for argon and 0.53 for helium. The corresponding values for clean tungsten were 0.82 and 0.17. Taking the value of d necessary to give this ratio of 4.8:1.0 with Zener's formula, we get $d=3.2(10)^{-10}$ cm.

The absolute value obtained for helium is somewhat higher than that found by Roberts. The reason is probably to be found in the roughness of the tungsten surface. It was found that prolonged heating gave constant values of the accommodation coefficient against clean tungsten, so we may probably assume that this roughness did not increase after a certain amount of heating. This is further confirmed by the fact that my values are in the upper range of the values found by Roberts. If we take his values of 0.20 and 0.06 for helium against a smooth oxygen covered surface and a smooth clean surface as correct and compute by his formula the average number of collisions made between a helium atom and my rough surface, we obtain 3.4 for the oxygen covered surface and 3.0 for the clean

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[1] C. Zener, Phys. Rev. **40**, 335 (1932).

[2] J. K. Roberts, Proc. Roy. Soc. **A129**, 146 (1930).

[3] J. K. Roberts, Proc. Roy. Soc. **A135**, 192 (1932).