A Decrease in the Electrical Resistance of Gold with a Magnetic Field at Low Temperatures

In connection with another investigation we have made measurements on the resistance of a sample of gold wire to which 0.1 percent of silver had been added. At about 8°K the resistance passes through a minimum and at 2°K it has increased about 3 percent above the minimum value. This effect has been observed previously by de Haas, de Boer and van den Berg[1] and the present observations are in agreement with their results. The minimum resistance is 0.0957 of the value at the ice point.

We have also made measurements in the presence of a magnetic field at liquid helium temperatures. At 4.23° the resistance increased with a magnetic field; however, at 1.63°K the resistance decreased by over 1 percent when a field of 8000 gauss was applied. The data are shown in Table I. A more complete study is in progress. The sample consisted of number 40 wire wound on a spool, the axis of which was parallel to the magnetic field.

TABLE I. *Change of resistance of gold with a magnetic field.*

$T=1.63°K$		$T=4.23°K$	
H_{Gauss}	$(\Delta R/R)\times 10^4$	H_{Gauss}	$(\Delta R/R)\times 10^4$
1630	−5.1	1630	+2.8
2450	−10.5	2450	4.8
3300	−18.7	3230	6.4
6110	−62.2	6040	15.7
8490	−112.3	8490	26.8

The above reversal in sign and the minimum in resistance are presumably related. A decreasing resistance with magnetic field has previously been observed only in the case of ferromagnetic metals and has been ascribed to effects related to ferromagnetism. A series of gold-silver alloys covering the range 10 to 90 mole percent was also investigated. These materials have no appreciable temperature coefficient of resistance below 10°K and their resistance is practically independent of magnetic field to 8000 gauss.

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[1] de Haas, de Boer and van den Berg, Physica **1**, 1115 (1934); de Haas and van den Berg, Physica **3**, 440 (1936).

Connection Between the Second Virial Coefficient and the Phases of Collision Theory

In a recent paper on "Quantum Theory of the Equation of State at Low Temperatures"[1] the writer derived the exact quantum formulae for the second virial coefficient for gases obeying the various statistics, the one for the Einstein-Bose statistics, for example, being, in the absence of any discrete state,

$$B=-\frac{N\pi^{\frac{3}{2}}\lambda^3}{2}+2\sum_{\text{even } l}(l+\tfrac{1}{2})B_l \qquad (1)$$

with the same notation as in the paper cited.

For high temperatures, it was there shown how the quantum formulae for all statistics go over to the classical. Up till now, however, no satisfactory formula has been developed for the low temperature region. And it is just this region which is the most interesting, for at low enough temperatures, it should be possible to verify experimentally, at least for helium, the difference between the statistics theoretically predicted. This ought to be possible since at the lowest temperatures the virial coefficient for the Einstein-Bose statistics is theoretically twice as large as for the Boltzman statistics. And even though the Slater-Margenau potential may be quite inaccurate, there is a margin of a hundred percent difference between the two statistics, which leaves room enough to decide from the experimental data—all the more so, since, as we shall show in a later paper, the virial coefficient is relatively not so sensitive to the potential at the lower temperatures.

In the attempt to find an expression for the virial coefficient valid at low temperatures, the writer was led to derive an *exact* expression for B_l. The result is simply

$$B_l=-8\pi^{\frac{1}{2}}\lambda^3N\int_0^\infty dke^{-\lambda^2k^2}d\eta/dk, \qquad (2)$$

where η is the phase shift in the wave function for two radially interacting molecules. *This expression is valid over the whole temperature region.* The proof will be left to a later paper. We will only show here, that for the case of rigid spheres (2) reduces to the formula given by Uhlenbeck and Beth.[2] For, with rigid spheres,

$$\eta=-\tan^{-1}\left(\frac{J_{l+\frac{1}{2}}(k\sigma)}{J_{-l-\frac{1}{2}}(k\sigma)}(-1)^l\right),$$

so that

$$\frac{d\eta}{dk}=-\frac{2}{\pi k}\frac{1}{J^2_{l+\frac{1}{2}}(k\sigma)+J^2_{-l-\frac{1}{2}}(k\sigma)}.$$

Substitution in (2) gives the Uhlenbeck and Beth result.

This work will be developed more fully when the calculation for the phases is completed.

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May 18, 1937.

[1] L. Gropper, Phys. Rev. **50**, 963 (1936).
[2] G. E. Uhlenbeck and E. Beth, Physica **3**, 729 (1936).

On the Effects in Cosmic-Ray Intensity Observed During the Recent Magnetic Storm

The purpose of this letter is to indicate some effects in cosmic-ray intensity which were observed simultaneously at two stations during the magnetic storm of April 25 to 30, 1937. The data were obtained with Compton-Bennett meters, one at the Cheltenham (Maryland) Magnetic Observatory of the United States Coast and Geodetic Survey and the other at the Huancayo (Peru) Magnetic Observatory of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. The accompanying figure summarizes the observed effects. On it are plotted for the two stations, in Greenwich mean time, the departures, in percent of the absolute value, of each bi-hourly