On the Quantum Theory of the Temperature of Absolute Zero

(with G. Beck and W. Riezler)

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This joke was meant to make fun of papers by Eddington in which he claimed to derive the value of the fine structure constant to be $1/\alpha = \hbar c/e^2 = 137$. He started from Dirac's theory which uses a 4×4 matrix for an electron. Dirac had (erroneously) assumed that a proton is a hole in the, generally filled, sea of negative energy states of the electron, so Eddington assumed there should again be a 4×4 matrix pertaining to a proton. For a proton and an electron, the two elementary particles then known and interacting by electric forces, you would then need a 16×16 matrix which, if symmetric, has 136 distinct matrix elements. Add one for the orbital motion of the electron around the proton makes 137 "digress of freedom", a number close to the then known value of $1/\alpha$. Modern measurements give 137.0360.

Beck, Riezler and I were at Cambridge on fellowships and had listened to Eddington's unbelievable talk about the number 137.

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Let us consider a hexagonal lattice. The absolute zero of the lattice is characterized by the fact that all degrees of freedom of the system are frozen out, i.e. all inner movements of the lattice have ceased, with the exception, of course, of the motion of an electron in its Bohr orbit. According to Eddington every electron has $1/\alpha$ degrees of freedom where α is the fine structure constant of Sommerfeld. Besides electrons our crystal contains only protons and for these the number of degrees of freedom is obviously the same since, according to Dirac, a proton is considered to be a hole in a gas of electrons. Therefore to get to the absolute zero we have to remove from the substance per neutron (= 1 electron plus 1 proton; our crystal is to carry no net charge) $2/\alpha - 1$ degrees of freedom since one degree of freedom has to remain for the orbital motion. We thus obtain for the zero temperature

$$T_0 = -(2/\alpha - 1) \text{ degrees.}$$

Putting $T_0 = -273°$, we obtain for $1/\alpha$ the value 137 in perfect agreement within the limits of accuracy with the value obtained by totally independent methods. It can be seen very easily that our result is independent of the particular crystal lattice chosen.

G. Beck, H. Bethe, W. Riezler
Cambridge, 10 December 1930

"Correction"

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The note by G. Beck, H. Bethe and W. Riezler, published in the January 9 issue of this journal, was not meant to be taken seriously. It was intended to characterize a certain class of papers in theoretical physics of recent years which are purely speculative and based on spurious numerical agreements. In a letter received by the editors from these gentlemen they express regret that the formulation they gave to the idea was suited to produce misunderstanding.