LETTERS TO PROGRESS IN PHYSICS

On the True Dimensionality of Electric Charge and Some Thermodynamic Quantities

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An additional justification for the nature of electric charge as momentum is provided, and its relationship with thermodynamic parameters is demonstrated. A new interpretation of the Boltzmann constant, temperature, and entropy is given.

It is obvious that the dimensions of the electron charge (i.e., Coulomb) and temperature (degrees of Kelvin) merely denote these fundamental concepts, but do not clarify their essence. For example, the Coulomb and Ampere forces can be expressed without using the actual magnitude of the charge; it is sufficient to simply substitute the number of charges contained in the interacting objects into the formulas [1].

In the author's previous works, where the mechanistic interpretation of J. Wheeler's geometrodynamics was used, we proposed to consider the charge as the limiting momentum of an electron $m_e c$ [1, 2], which allowed to determine a number of parameters of the microworld [3].

Moreover, the correctness of this particular solution also follows from the dimensionality of thermodynamic quantities.

For example, the Boltzmann constant, a physical constant that determines the relationship between temperature and energy, is calculated experimentally and equals 1 in the International System of Units

$$k_B = 1.38 \times 10^{-23} \text{ J/K}. \tag{1}$$

The Boltzmann constant bridges the gap between the macrocosm and the microcosm, linking absolute temperature T with the kinetic energy of molecules

$$E = \frac{3}{2}\, k_B T, \tag{2}$$

and also it determines entropy

$$S = k_B \ln Z, \tag{3}$$

where Z is the number of different microstates. The Boltzmann constant also appears in many other thermodynamic formulas.

However, the exact value of k_B is determined by the ratio of Planck's constant to the speed of light and the electron charge:

$$k_B = \frac{h}{c\, e_0}, \tag{4}$$

but the source of this is unclear, because the dimension of k_B is completely different. Due to the discrepancy in dimensions, this fact is not indicated in the scientific and technical literature.

However, if we consider the electron's charge as momentum, then the dimension of k_B becomes [sec], which is equal in magnitude to the time it takes light to travel a distance close to the size of an electron. Then the dimension of temperature [K] becomes physically understandable and obvious, namely, — it is the power of the chaotic kinetic motion of microparticles [J/sec].

In addition, it should be noted, and this is apparently not accidental, that when a person is moving or during moderate work (expended power is about 1000 kJ/hour), the most comfortable temperature for a person is (16–20°C), which just corresponds to the same power of chaotic kinetic movement of microparticles at a temperature of about 290°K:

$$N = \frac{290 \times 3600}{1000} = 1040 \text{ kJ/hour}. \tag{5}$$

Thus, humans as biological entities are completely consistent with their natural environment, both at the macrocosmic and microcosmic levels.

As for entropy, it becomes time rather than specific energy, which is much more consistent with its physical meaning and our intuitive perception.

Indeed, according to the recent scientific publication [4], Prof. Giovanni Barontini (the University of Birmingham) has established that changes in entropy themselves behave like time.

In his laboratory, he created a miniature "universe" of 24,000 ultra-cold atoms that repeatedly expanded and contracted, resembling a scenario in which the expansion of the universe eventually reverses. As this collective of atoms evolved, the system moved forward in time, and when the changes ceased, time effectively stood still. The rate of time could accelerate or decelerate depending on the entropy shift within the system.

Thus, Barontini experimentally demonstrated that within an isolated quantum system, it is possible to define a true time based solely on the change in entropy and the redistribution of particles within the system, without any external references.

This entropic time not only orders events but also obeys a modified Schrödinger equation.

One can roughly estimate the cycle time (entropy) in the Barontini experiment, knowing the volume of an Rb atom, about 10^{-28} m^3, their total volume, $w = 2.4 \times 10^{-24}$ m^3, and the volume of the experimental chamber W. Then, assuming that all rubidium atoms are indistinguishable, the total number of their permutations will be:

$$Z = (W/w)! = n!\,, \tag{6}$$

where the factorial is calculated using Stirling's formula

$$n! = (2\pi n)^{1/2} \left(\frac{n}{e}\right)^n. \tag{7}$$

Let us assume that the chamber had a volume W in the range of $10^{-4} \ldots 10^{-6}$ m^3, then by substituting the parameters into formulas (6), (7) and (3) we can estimate the entropy (cycle time): namely, $S = 0.26 \ldots 0.0024$ sec, which is consistent with the experimental results (hundredths of a second).

It can be concluded that as the number of particles in the "microuniverse" decreases, the cycle of changes will shorten, and as the system shrinks to the size of a microworld, the duration of the cycle will reach a value at which it will become impossible to observe internal changes in the system; in this case, time becomes indefinite or disappears altogether.

Indeed, as D. I. Blokhintsev asserted in his monograph [5]: "…in quantum mechanics, time t is considered essentially unequal to spatial coordinates […] the finite dimensions of real particles exclude the possibility of measuring the variables x and t inside the particles, and thus the physical reality of these variables is called into question […] the concept of a causal sequence of events loses its meaning, and we will be dealing with a connected "lump" of events that mutually determine each other, but do not follow one from another […] such realities cannot be ordered in time: the concepts of 'earlier' and 'later' do not exist for them…".

Thus, from our point of view, time in the microworld is actually undefined and, perhaps, it does not exist there at all.

As a result, we received additional justification for the nature of charge as an impulse, and also revealed the physical essence of the Boltzmann constant, absolute temperature, entropy, and made the assumption that in the microworld, time as an objective parameter is absent.

The calculation of the cycle parameters in the Barontini experiment confirms the above statements.

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References

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