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A New Approach to Establishing Mass-Energy Equivalence

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Abstract

In the present work, Einstein's formula, which establishes mass-energy equivalence, has been obtained using Joule's law. For this purpose, the equality of the kinetic energy of the translational motion of molecules to the amount of energy released by direct current in the form of heat is used. It is noted that the emerging direct current is equivalent to the voltage drop at the ends of the resistance in a finite time. Attention is drawn to the fact that the translational velocity of electrons for different metals is different, and the speed of light is the limit to which only the velocities of electrons in different metals can tend. The proposition is used according to which the dimension of resistance is inverse to the dimension of velocity. As a result of taking into account this proposition and Einstein's second postulate, on the basis of Joule's law, a ratio establishing mass-energy equivalence has been obtained.

Subject Areas

Particle Physics

Keywords

Einstein Formula, Joule's Law, Kinetic Energy, Equivalent, Mass, Dimension, Second Postulate, Resistance, Voltage, Heat, Light Velocity, Install, Direct Current, Charge, Different Metal, Electron

1. Introduction

Using the Lorentz transformation and the concept of kinetic energy, A. Einstein, in 1905, obtained the main result of the theory of special relativity [1]—a formula establishing mass-energy equivalence:

$$E = Mc^2, \tag{1}$$

where E is kinetic energy, M—mass, c—speed of light in vacuum.

The mass has two forms: inertness and gravitation. Formula (1) the inertness of energy is called [2].

2. Derivation of Einstein's Energy Formula with a New Approach

In this paper, to obtain Formula (1), Joule's law is used, which states that the amount of heat Q released by direct current I per unit time when it flows through resistance R is determined by the ratio:

$$Q = RI^2 . \tag{2}$$

According to the classical statistical theory, the average kinetic energy E of the translational thermal motion of molecules having a mass m^* and root-mean-square velocity v_{rms}^2 is proportional to the absolute temperature T_a, *i.e.* the amount of energy released in the form of heat Q:

$$E \equiv \frac{1}{2} m^* v_{rms}^2 = \frac{3}{2} KT_a \equiv Q , \tag{3}$$

where K is Boltzmann's constant.

The validity of Formula (3) can be seen if we take into account that E and Q have one and the same dimension:

$$[Q] = [E] = L^2 MT^{-2} ,$$

where M is dimension of mass (kilogram); L—dimension of length (metre); T—dimension of time (second).

Equation (3) makes it possible to use the concept of the amount of heat instead of the concept of energy.

For direct current I, the formula is valid

$$I = \frac{q}{t} , \tag{4}$$

where q is electric charge, t—finite time.

The emergence of a current caused by an electric charge q is equivalent to a voltage drop $\Delta U = U_1 - U_2$ at the ends of the resistance R over a finite period of time; the voltage drop creates an electric field that causes translational motion of electrons, *i.e.* current. Therefore, direct current is equivalent to a voltage drop over a finite time (4)

$$I = \frac{\Delta U}{t} . \tag{5}$$

Operating time of the current when it is passed through the resistance R is

$$t = \frac{R}{c^*} , \tag{6}$$

where

R—resistance is defined as length dimension, *i.e.* $R = L$,

c^* is velocity of electrons in a particular metal.

Substituting the value t from (6) into (5) allows determining the current:

$$I = \frac{\Delta U c^*}{R}. \tag{7}$$

Taking into account the Formula (7) in the Joules relation (2) gives

$$Q = R\frac{1}{R^2}\left(\Delta U c^*\right)^2. \tag{8}$$

To remove from consideration the component $\Delta U c^*$, it is necessary to take into account the second postulate of Einstein: the speed of light in an arbitrary frame of reference has the same value. If we put the speeds of light in different metals in ascending order, then this postulate can be formulated as follows: the speed of light c is the limit to which only the speeds c^* of electrons in different metals can strive, but they can neither reach nor exceed it, *i.e.*, $c^* < c$. In order to use speed instead of the term R^{-2} in Formula (8), it is necessary to take into account the fact that the dimension of resistance is inverse to the dimension of speed [3]: $[R] = L^{-1}T$. If we use this statement for the speed of light c in relation to Formula (8) and take into account in it the rule for adding the speed of light $c + c^* = c$, according to Einstein's postulate, then we get

$$Q = Rc^2. \tag{9}$$

If we take into consideration correlations (2) and (3), then Formula (9) can be written as following

$$E = Rc^2. \tag{10}$$

It is widely known that the following definition of energy takes place

$$E = N \cdot m = \frac{kgm}{s^2} \cdot m = kg\left(\frac{m}{s}\right)^2 = kg \cdot v^2, \tag{11}$$

where v is velocity, N—Newton, m—meter, s—second, kg—kilogram.

In order to preserve the symmetry of expression (10) with respect to the speed of light, it is necessary to take $v = c$ in the definition (11). In this case, taking into account definition (11), the relation (10) can be written in the form

$$kg = R.$$

The last expression means that R is mass ($R = M$) measured in kilograms; therefore, the equality of mass and energy is set by Formula (10)

$$E = Mc^2.$$

This formula coincides with the Einstein relation (1).

3. Conclusion

Using the law of Joule (2), relation (3), the second postulate of Einstein, the resistance dimension is in verse of the velocity and in Formula (11), the main result is obtained.

Conflicts of Interest

The author declares no conflicts of interest.

References

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