Einstein's Total Relativistic Energy and the Scale Law

Abstract

Earlier this year I wrote an article entitled The Scale Law. In that article I formulated a new meta-law which all laws of physics obey. The purpose of this article is to show that the Einstein's relativistic energy formula is a special case of the present formulation.

by R. A. Frino
Electronics Engineer
v1: 2012 – v3: 2017

Keywords: *total relativistic energy, momentum, rest mass, the scale law.*

Contents

1. Introduction

In 2012 I formulated the scale law (or scale principle) [1] which I published in June this year. The scale law states that the laws of physics can be written as dimensionless ratios, Q_1/Q_2 and Q_3/Q_4 , with a dimensionless scale factor (or scaling factor), *S*. In other words the scale law can be expressed, mathematically, by the following relationship:

Scale Principle or *Scale Law*

$$\left(\frac{Q_1}{Q_2}\right)^n \text{ operator } S\left(\frac{Q_3}{Q_4}\right)^m \quad (1.1)$$

Where *operator* denotes a relational operator. Relational operators can be any of the following: equal to, $=$; greater than, $>$; less than, $<$; greater than or equal to

≥ ; less than or equal to ≤ ; approximately, ≈ , etc. See reference [1] for a full description of the scale law.

2. Derivation of Einstein's Total Relativistic Energy Equation from the Scale Law

I shall derive the Einstein's total relativistic energy [2, 3] formula:

$$E^2 = p^2 c^2 + m_0^2 c^4 \tag{2.1}$$

from the scale law. Let us consider the energy scale table given below. I don't include the scale factor in the table for simplicity reasons. However, the scale factor must be included in the relationship we are looking for.

Energy	Energy	Energy	Energy
E_1	E_2	pc	pc

***Table 1**: This simple scale table is used to show that Einstein's relativistic energy equation obeys the scale law.*

Where

E_1 = energy (the meaning is given below)
E_2 = energy (the meaning is given below)
p = momentum of the particle
c = speed of light in vacuum

According to the above scale table we write the following relationship

$$E_1 E_2 = S\, pc\, pc \tag{2.2}$$

As always we have introduced the scale factor, *S*. Equation (2.2) is one form of the scale law. However, a more convenient way of writing the scale law is to express it as a relation between two ratios:

$$\frac{E_1}{pc} = S \frac{pc}{E_2} \tag{2.3}$$

The meaning of E_1 and E_2 is given by the following definitions

(2.4)

$$E_1 = E + m_0 c^2$$

E_1 is the particle’s relativistic energy plus its rest energy, and

$$E_2 = E - m_0 c^2 \qquad (2.5)$$

E_2 is the particle’s relativistic energy minus its rest energy.

Where

E = total relativistic energy of the particle
m_0 = particle’s rest mass

Substituting E_1 and E_2 in equation (2.3) with the second side of equations (2.4) and (2.5) respectively, we get

$$\frac{E + m_0 c^2}{pc} = S \frac{pc}{E - m_0 c^2} \qquad (2.6)$$

A scale factor of 1 yields the total relativistic energy in the form of the scale law

The scale law for Einstein's relativistic energy formula

$$\frac{E + m_0 c^2}{pc} = \frac{pc}{E - m_0 c^2} \qquad (2.7)$$

The reason I chose this value for the scale factor is that all complete energy laws appear to have a scale factor of either 1 or -1 [4]. Comparing eq. (2.7) with eq. (1.1) we get the following relations

$n = m = 1$
$Q_1 = E + m_0 c^2$
$Q_2 = Q_3 = pc$
$Q_1 = E - m_0 c^2$
$S = 1$

(Another way of obtaining the value of the scale factor is through experiments. Let's not forget that Einstein's relativistic energy formula was compared over and over again with experimental evidence to prove its correctness).
Thus, equation (2.7) corresponds to the following simple case of the scale law:

$$\frac{Q_1}{Q_2} = \frac{Q_3}{Q_4} \qquad (2.8)$$

Where $Q_2 = Q_3$. Now let us return to equation (2.7) and rewrite it as follows

$$(E + m_0 c^2)(E - m_0 c^2) = (pc)^2 \qquad (2.9)$$

$$E^2 - \left(m_0 c^2\right)^2 = (pc)^2 \qquad (2.10)$$

Finally

$$E^2 = p^2 c^2 + m_0^2 c^4 \qquad (2.11)$$

Thus we have derived Einstein's formula for the total relativistic energy of a particle from the scale law. Undoubtedly, observing equation (2.11) is almost impossible to suspect that this equation obeys the scale law.

There is a shorter and easier way of proving that eq. (2.11) obeys the scale law. We could have started with equation (2.11) (without drawing the scale table) and then we could have worked back through equations (2.10), (2.9), (2.8) until we get to equation (2.7). However, this backward process can not be applied unless we know the final equation that is unknown when it comes to unknown phenomena.

3. Conclusions

Critically speaking, we might say that, in order to determine the value of the scale factor, we had to look at the experimental evidence. However, this is also the case with Einstein's special theory of relativity which was based on experiments (Michelson-Morley) which showed that the velocity of light in vacuum was independent of the motion of the light source (a postulate known as the invariance of *c*). Einstein adopted this experimental result as one of his postulates or cornerstones to formulate his special theory of relativity. Therefore, the derivation presented in this paper is as solid as any theory based on postulates inferred from experimental results.

However, I have recently found (2017) that all complete energy laws appear to have scaling factors with absolute values equal to 1 [4]. Thus, this is a compelling reason to use this value.

In summary, taking into consideration that the scale law describes all known laws of physics as I have shown in previous papers [1, 5] and in this paper, we can consider that the scale law is a more general and higher law than the specific laws it describes. In other words, the scale law can be regarded as a meta-law.

REFERENCES

[1] R. A. Frino, *The Scale Law*, viXra.org 1405.0270, (2014).
[2] A. Einstein, *Does the Inertia of a Body Depend Upon Its Energy Content?*, (1905).
[3] A. Einstein, *Elementary Derivation of the Equivalence of Mass and Energy*, *Am. Math. Soc. Bul.* 41:223-230, (1935).

[4] R. A. Frino, On the Scale Factors of Energy Formulas, viXra.org 1405.0199, (2017).
[5] R. A. Frino, *Where Do the Laws of Physics Come From?,* viXra.org 1407.0103, (2014).