How to Generalize Incomplete Physical Laws

This work refers to a method of generalizing incomplete physical laws through the scale law. Generalization can only be applied when the general law exists but has not yet been discovered. It is remarkable that the very simple methodology described in this paper turns out to be so powerful.

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2017

***Keywords**: Total relativistic energy, energy-time special universal uncertainty relation, momentum-position special universal uncertainty relations, Planck's constant, Planck length, Planck time, scale law, scale factor, complete physical law, incomplete phisical law.*

Contents

1. Complete and Incomplete Laws of Physics

I shall begin by defining two concepts: (a) complete laws of physics and (b) incomplete laws of physics. Let us have a look at the definitions:

(a) COMPLETE LAWS OF PHYSICS
A complete law of physics is a physical law that can be expressed as

Definition of a complete physical law (unspecified relationship)

$$\frac{X_a}{X_b}\ operator\ S\frac{X_c}{X_d} \tag{D.1}$$

The *operator* (relational operators) can be any of the following: equal to, $=$; greater than, $>$; less than, $<$; greater than or equal to $\geq$; less than or equal to $\leq$; approximately, $\approx$, etc. Most of the time we shall see the equal sign of an equation, such as

Definition of a complete physical law (specific relationship: equation)

$$\frac{X_a}{X_b} = S\frac{X_c}{X_d}$$

Where X_a , X_b , are variables whose units are identical (e.g. units of energy, units of length, units of time, units of mass, etc) and X_c , X_d are variables whose units are also identical. However the units of X_a and X_b could be either equal or different to the units of X_c and X_d . *S* is the scale factor (or scaling factor if you like). *S* is always a dimensionless real or imaginary number. A complete physical law satisfies one and only one of the following conditions

Condition 1
$$X_a \neq X_d \quad \text{and} \quad X_b = X_c \tag{1.1a}$$

Condition 2
$$X_a = X_d \quad \text{and} \quad X_b \neq X_c \tag{1.1b}$$

Condition 3
$$X_a \neq X_b \neq X_c \neq X_d \tag{1.1c}$$

(a) INCOMPLETE LAWS OF PHYSICS

An incomplete law of physics is a physical law that can be expressed as

Definition of an incomplete physical law (general relationship)
$$\frac{X_a}{X_b} \ operator \ S \tag{D.2}$$

The relational operators are the same as described above. Most of the time we shall deal with relationships of the type

Definition of an incomplete physical law (specific relationship: equation)

$$\frac{X_a}{X_b} = S$$

Where X_a , X_b , are variables whose units are identical (e.g. units of energy, units of length, units of time, units of mass, etc.). Of course, to have a relationship the following condition will apply

$$X_a \neq X_b \tag{1.1d}$$

The basic difference between complete and incomplete laws is that a complete law is more general than the incomplete counterpart. In other words, a complete law is a generalization of the incomplete counterpart. References [1, 2] provide more information about the scale law.

2. Examples of Incomplete Laws and Their Corresponding Complete or General Counterparts

The following table shows three physical laws that have been generalized (although through different approaches). The laws shown here could be considered as examples of the approach followed in this paper.

INCOMPLETE LAW (expressed according to the scale law)	COMPLETE LAW (general law expressed according to the scale law)	COMPLETE LAW (general law expressed in a familiar way)
Photon energy $\frac{E}{pc}=1$ [4]	$\frac{E_1}{pc}=\frac{pc}{E_2}$ [4]	Einstein's total relativistic energy $E^2=p^2c^2+m_0^2c^4$ [4]
Heisenberg uncertainty relation $\frac{\Delta E}{\frac{\hbar}{2\Delta t}}\geq 1$ [4]	$\frac{\Delta E-\frac{\hbar}{2\Delta t}}{\frac{\hbar}{2\Delta t}}\geq -\frac{\frac{\Delta E\, T_P}{2\Delta t}}{\Delta E+\frac{\hbar}{2\Delta t}}$ [4]	Energy-time universal uncertainty relation $\Delta E\,\Delta t\geq\sqrt{\frac{\hbar^2}{4}-\frac{\hbar}{4}\Delta E\, T_P}$ [3, 4]
Heisenberg uncertainty relation $\frac{\Delta p_x}{\frac{\hbar}{2\Delta x}}\geq 1$	$\frac{\Delta p_x-\frac{\hbar}{2\Delta x}}{\frac{\hbar}{2\Delta x}}\geq -\frac{\frac{\Delta p_x L_P}{2\Delta x}}{\Delta p_x+\frac{\hbar}{2\Delta x}}$	Momentum-position universal uncertainty relation $\Delta p_x\,\Delta x\geq\sqrt{\frac{\hbar^2}{4}-\frac{\hbar}{4}\Delta p_x L_P}$ [3]

Table 1: The first column shows incomplete laws. The second column shows the corresponding complete or general laws written in the form of the scale law. The third column shows the same complete laws written in a more familiar way. The last row shows a hypothetical law yet to be discovered. The momentum-position universal uncertainty relations for the *y* and *z* axes are not shown.

The first row of the table corresponds to the photon energy (incomplete law) and the Einstein's total relativistic energy law (general law). The second row corresponds to the energy-time Heisenberg uncertainty relation (incomplete law) and the energy-time universal uncertainty relation (general law) and, finally, the third row corresponds to the momentum-position Heisenberg uncertainty relation (incomplete law) and the momentum-position universal uncertainty relation (general law).

3. Conclusions

One point I would like to mention is that the term "incomplete" has two different connotations: (i) it refers to a physical law that satisfies the above definition (D.2) and, in addition, turns out to be a particular case of a more general law; and (ii) refers to a law that satisfies the above definition (D.2), but does not allow generalization.

In conclusion, the approach followed here is a powerful method for finding undiscovered general formulations from incomplete physical laws (in the sense given by connotation (i)). However, not all physical laws can be generalized, regardless of what method we use to do so. So the main problem we face is finding an incomplete law that can be generalized.

Appendix 1
Nomenclature

I shall use the following nomenclature for the constants and variables used in this paper. (Please refer to reference [4] for more details on the variables used in this paper such as E_1 and E_2).

X_a = variable
X_b = variable
X_c = variable
X_d = variable
S = scale factor or scaling factor
c = speed of light in vacuum
E_1 = is the total relativistic energy of particle 1 plus its rest energy
E_2 = is the total relativistic energy of particle 2 minus its rest energy
E = total relativistic energy of the particle
p = momentum of the particle
m_0 = rest mass of the particle
h = Planck's constant
$\hbar$ = reduced Planck's constant $(\hbar = h/2\pi)$
L_P = Planck length
T_P = Planck time
ΔE = uncertainty in energy
Δt = uncertainty in time
Δp_x = uncertainty in momentum
Δx = uncertainty in position
f = frequency of a photon

REFERENCES

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