The Organizational Structure of Physics

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Although each area of physics is known and codified in the form of a specific system of equations, the lack of standardization prevents us from recognizing the common underlying organizational structure of physical interactions. This paper explores the possibility that all areas of physics share a common operating mechanism and presents a formalization of their inner working.

1. Introduction

Even if we have a good knowledge of the set of equations governing the various fields of physics, there is still no generalized uniform framework to describe interactions between physical quantities. This paper presents a formalism that provides a new approach of the organizational structure of physics, fully compatible with current knowledge, leading to the categorization of physical quantities with respect to their role and the generalization of the equations that govern their interactions.

1.1. Basic Concepts

The proposed formalism is associated with the concept of radiation or conduction of different forms of energy [1]. We know that there are some operational similarities among the various areas of physics and the correspondence between equations pertaining to different domains allows us to suspect a deep functional identity with different quantities playing a similar role but using different symbols or quantities sharing a common name but playing different roles. The different expressions of the well known equations presented in Table 1 are a good illustration of these similarities [2].

	Gravitic	Electric	Magnetic
Interaction force	$G\frac{M_1 M_2}{r^2}$	$K\frac{Q_1 Q_2}{r^2}$	$\frac{\mu}{4\pi}\frac{I_1 d_1 \times I_2 d_2}{r^2}$
Potential Energy	mgh	QU	IsB
Kinetic Energy	$\frac{1}{2}mv^2$	$\frac{1}{2}CU^2$	$\frac{1}{2}LI^2$
Power	$\dot{m}gh$	UI	$\frac{BIs}{t}$

Table 1. Physics equations

Considering these equations, we can say that they relate to different domains of physics and that each term belongs to specific groups with respect to the nature of their influence in the equation. Finally, we intuitively understand that each term of an equation plays a specific role as it has a numerical and a dimensional influence on the result of the equation.

1.2. Space-Time Organization

A simple way to represent physical quantities in space-time coordinates and clearly highlight their dimensional relationships is with a matrix, whose horizontal axis corresponds to space, while the vertical axis corresponds to time as shown in Fig. 1.

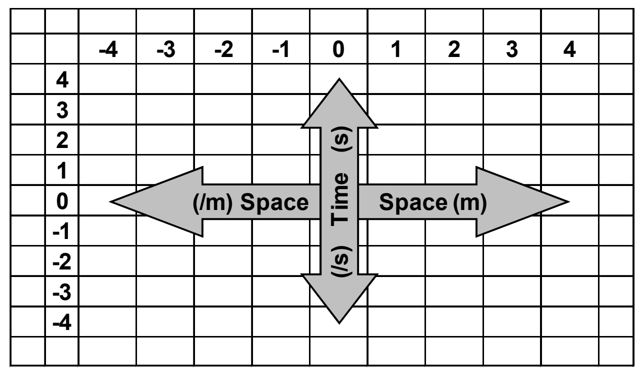

Fig. 1. The Space-Time Matrix

Understandably, any horizontal shift of one cell corresponds to a multiplication or division by meters, while a vertical shift corresponds to a multiplication or division by seconds. It becomes easy to produce such a matrix to represent the elements connected by space or time. By this matrix will be shown the structure of different areas of physics, relations between physical quantities, and the fundamental importance of their roles.

2. Organizational Structure

Domains, Groups and Roles are three basic concepts of the proposed formalism.

2.1. Domains

A domain is basically one of the well known areas of modern physics. There are two special domains and four standard domains as illustrated by Fig. 2.

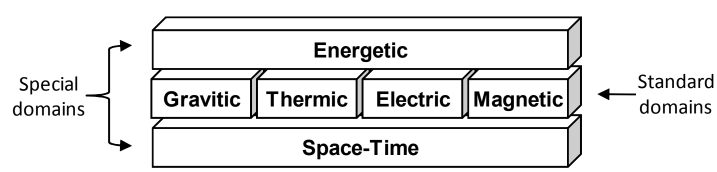

Fig. 2. Domain structure

The two special domains are the Space-Time domain in which we find the elements of the space-time continuum, and the energetic domain that contains the quantities associated with the measure of energy radiation or conduction. The standard domains correspond to the well known different forms of energy such as gravitic, electric, magnetic and thermic.

2.2. The Space-Time Domain

The Space-Time domain brings together elements associated with the space-time continuum that can locate and measure a physical interaction in space and in time. These elements, along with their space-time representation using the concept of the dimensional matrix, are presented in Fig. 3:

Quantity	Symbol	Relation
Length or distance	l or d	d
Surface	s	d*d
Volume	v	d*d*d
Time	t	t
Frequency	f	1/t
Velocity	c	d/t

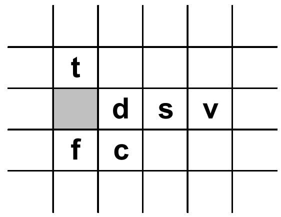

Fig. 3. SpaceTime domain elements

The real basic elements of the Space-Time domain are in fact only distance and duration while others are just the derivatives and could theoretically extend to infinity. For example, since length, area and volume represent a unit distance to the power 1, 2 and 3 respectively (m^1, m^2, m^3), it is easy to envision a hypervolume of power 4 and so on. All symbols used to describe the SpaceTime domain elements are lowercase letters.

2.3. Standard Domains

The implementation of physical laws in the real world actually lies in the standard domains' operational mechanism. Remember that the Space-Time domain brings the metrics framework and is used to localize interactions, while quantities of the energetic domain are the measurable result or cause of these interactions. Consequently, with the exception of the elements of Space-Time and energetic domains, all known physical quantities belong to one of the standard domains: **Gravitic**, **Electric**, **Magnetic** and **Thermic**. By performing a normalization of roles and symbols, this study will highlight the operating similarity between these domains. All equations describing an interaction pertaining to a standard domain respect the following fundamental axiom: **Effect = Cause / Opposition** and by symmetry, the inverse of Opposition being Promotion: **Effect = Cause * Promotion**. It is through this concept that will be highlighted the basic roles of standard domains' physical quantities. It will then be important to recognize in each studied equation the elements that represent the cause, the effect, the promotion or the opposition of the described phenomenon. All standard domains share an identical structure and operating mechanism presented in the following sections. Each of them contains an identical set of physical quantities corresponding to normalized roles presented in four groups.

2.4. Groups

The four groups categorize the elements of a standard domain based on their influence in a process described by an equation. Thus, all standard domains' physical quantities will be part of one of the groups listed in Table 2.

Each group presents a set of quantities whose role will conceptually correspond to the group definition. These quantities are intrinsically playing the same role, only with a different distribution in space or time. The relationships between resistance and resistivity or charge and current are a good illustration of this dimensional affinity. Consequently, any element of a specific group is linked with others elements of the same group only by space, time or both. It will then be possible to represent a group on a space-time matrix.

Name	Definition
Radiation	Quantities associated with energy radiation
Conduction	Quantities associated with energy conduction
Static	Quantities opposing conduction (promoting radiation)
Dynamic	Quantities promoting conduction (opposing radiation)

Table 2. Groups definitions

2.5. Roles

The behavior of a physical quantity lies in its role representing the function of the considered quantity, in other words, its influence on a relation represented by an equation. The roles are generally known, but suffer from a lack of generalization that affects our understanding of physical phenomena. Since every quantity involved in a formula has a numerical and dimensional influence, even tiny, all quantities must correspond to specific roles. Each role can then be categorized and assigned to one of the groups with respect to its influence. The fundamental Roles are identified in Table 3.

Group	Name	Definition
Conduction	Charge	Entity of a domain allowing energy radiation or conduction
	Charge distribution	Surface density of charge
	Charge density	Volume density of charge
	Current	Quantity of charges over time (flow)
	Current distribution	Surface density of current
Radiation	Flux	Influence of the charge on the medium
	Potential	Gradient of Flux
	Field	Surface density of Flux
Static	Resistivity	Opposition of the medium to temporal conduction (current)
	Resistance	Amount of resistivity per unit portion of the medium
	Rigidity	Opposition of the medium to spatial conduction (density)
	Rigidance	Amount of rigidity per unit portion of the medium
Dynamic	Conductivity	Promotion of the medium to temporal conduction (current)
	Conductance	Amount of conductivity times unit portion of the medium
	Permittivity	Promotion of the medium to spatial conduction (density)
	Capacitance	Amount of permittivity times unit portion of the medium

Table 3. Roles definitions

Role definitions are intentionally generic and carefully avoid any mention of specific domain because the proposed formalism suggests that the set of standard roles apply to all standard domains, which implies concepts as unusual as the magnetic charge or the gravitic permittivity for example. Furthermore, from the logic of groups definitions (space-time only relationship in a single group), when a member of a group is defined, the others are also automatically defined. For example, if a charge exists, then its flow, called a current, is implicitly postulated, and this, whatever the standard domain concerned. We can therefore have a current of electric charge, a current of mass or a current of heat for example. In most cases, these elements are known, but expressed in different forms and different symbols, such as a mass flow or a heat flux. The following sections will give a definition for each role of each group and demonstrate their relationships.

3. Roles of the Conduction Group

The Conduction Group contains items associated with energy conduction in a medium for all standard domains. Since energy conduction is obtained through charge displacement, the conduction group mainly contains the charge and all its derivatives. These elements and their space time representation are presented in Fig. 4.

Quantity	Symbol	Relation
Charge	Q	Q
Charge Distribution	D	Q / d^2
Charge Density	ρ	Q / d^3
Current	I	Q / t
Current Distribution	J	Q / (t * d^2)

	ρ	D		Q	
		J		I	

Fig. 4. Conduction group elements

Since it is suggested that the similarity of roles is complete across standard domains, a unique generic symbol for each role is suggested in the second column of the table. The third column shows the known dimensional space or time relationships between group members. For the conduction group, it would be trivial to demonstrate these relationships since they result directly from the definition of the elements. For example, a charge surface distribution is "by definition" equivalent to the dimension of the charge divided by square meters $D = Q/\mathrm{m}^2$. This, however, highlight the fact that once the position on the space-time matrix of one element of the group is raised, the position of all other members can be automatically and implicitly inferred from known relationships. This is true for all members of all groups of the standard domains, as well as for members of Space-Time and Energetic domains. The matrix representation presenting the spatiotemporal organization of groups is generic and valid for all standard domains. All the elements of a group of a standard domain will always be presented in the same way because of their spatial and temporal relationship. For example, a current will always be below a charge and a charge distribution is always two cells to the left of this charge, whatever the standard domain concerned. So if we accept for example a gravitic charge, we must also accept implicitly the gravitic current since these elements are connected within the Conduction group by a temporal relationship. As a consequence, once the charge of a domain is defined, all other elements of the Conduction group exist implicitly since they all have a well known spatiotemporal relationship with the charge. Additional roles such as the gradient of charge (Q/d), the gradient of current (I/d) or the current density (I/d^3) could easily be extrapolated and formalized in the Conduction Group.

3.1. Charge

Charge is the basic element of each domain and corresponds to something possessing an intrinsic energy influencing the surrounding medium (radiation) and the ability to occupy space and move (conduction). This study will not elaborate about the physical nature of the different charges because it is not necessary to understand the presented concepts and also because it would be the object of a whole study in itself. In the electric domain, the notion of charge corresponding to the given definition is very well known and expressed as Coulombs (C). The gravitic charge that has the ability to influence the medium and impose the force of gravity is called mass and is expressed in Kilograms (kg). The concept of magnetic charge has already been proposed by Paul Dirac in the form of magnetic monopole. This study does not imply that a magnetic monopole physically exists, but its mathematical existence as a unitary magnetic charge can be easily seen and used. There are several methods to find which unit corresponds to the hypothetical magnetic charge. For example, by analyzing the equation of the Lorentz force $F = QE + QvB$, and since force dimensionally corresponds to a charge multiplied by the intensity of the field in which it is immersed, it becomes clear that an electric charge multiplied by a velocity is equivalent to a magnetic charge ($Q_M = Q_E v$). Then, since the Coulomb per second corresponds to Amperes, the unity of the magnetic charge automatically becomes amperes times meters (A-m). The Thermic Charge corresponds to a quantity of heat whose Planck's quantum is represented by the Boltzmann constant (1.38E-23 J/K). This is confirmed by analysis of the similarities between electric and thermic equations where it is clear that heat represents the thermic charge.

3.2. Charge Distribution and Charge Density

Charge distribution and charge density, whose definitions are implicit because space exists, directly represent the spatial distribution of the charge in the medium. While the electric domain uses the term displacement field to designate the quantity corresponding to the charge distribution, if we examine its unit (C/m^2), its dimension (AT/L^2) or its definition $D = Q/s$, it is clear that the electric quantity usually characterized by the symbol *D* conceptually corresponds to a charge distribution over a surface. Based on the definition of the magnetic charge presented in the previous section, a magnetic charge distribution corresponds to amperes per meter (A/m). By analyzing the symmetry of electric and magnetic equations, it becomes evident that the role of magnetic charge distribution is assumed by the quantity called the auxiliary magnetic field or the magnetic excitation, usually represented by the symbol *H*. The gravitic and thermic charge distributions are expected by definition and naturally correspond to the unit of their charges divided by a surface, respectively Kilogram per square meter (kg/m^2) and Kelvin per square meter (K/m^2).

3.3. Current and Current Distribution

The concept of Current directly corresponds to the temporal distribution of charges called a flow, regardless of space, while Current Distribution integrates both time and space. Electric Current and Current Distribution are well known quantities, whose roles and dimensional relationship are obvious and compatible with the given definition. Thermic Current corresponds to a heat flow, also called a heat flux, and is naturally expressed in Kelvin per second (K/s). Gravitic Current will represent a mass transfer and naturally be expressed in kilograms per second (kg/s) or, in the case of a fluid flow, in liters per second (l/s) or meters cubed per second (m^3/s). In the magnetic domain, considering the charge unit mentioned previously, Magnetic Current automatically becomes Ampere - meters per second (A-m/s).

4. Roles of the Radiation Group

The Radiation group contains the elements associated with energy "Radiation", a term that originally means "emitted in rays", and a concept linked to the ability of a charge to impose a stress on the medium. The nature of this stress will depend on the concerned standard domain and is proportional to the distance from the charge. Fig. 5 presents the radiation group elements along with their space time matrix representation.

Quantity	Symbol	Relation
Flux	Φ	Φ
Potential	U	Φ / d
Field	E	Φ / d^2

	E	**U**	**Φ**	

Fig. 5. Radiation group elements

The relationships between members of the Radiation group such as Flux-Field for example are usually demonstrated through the various versions of the Gauss Law as illustrated by Table 4.

	Gravitic	Electric	Magnetic
Flux =	$\oint g\ dA$	$\oint E\ dA$	$\oint B\ dA$
	$-4\pi GM$	$4\pi KQ$	μId

Table 4. The Flux-defined by Gauss Law

4.1. Flux

The term Flux introduces an inherent initial ambiguity since it is associated with two separate roles. Considering its etymology meaning "flow", it is sometimes used to describe an amount of charge crossing a unit area. This is particularly true for the thermic and gravitic domains where we are talking about heat flux and fluid flow or flux. If we were to use this definition, the flux would be part of the Conduction Group, however, since we already have the term "current" to characterize this role, the term Flux will not be used in this sense. The term Flux will then describe the total capacity of a charge to influence the medium in which it is immersed. It is important to understand that in this definition, the flux concept loses its dynamic aspect as it is no longer associated with time but only with space. It will rather be defined as the extent of the alteration of the medium created by a charge, ignoring the geometry of the latter. The flux then corresponds to the intrinsic energy that a charge uses to influence its environment and can be inferred from the field measured through a surface, $\Phi = Es$, or directly deduced from the interaction between the charge and the medium, $\Phi = Q/\varepsilon$. In electromagnetism, the electric and magnetic flux are well known and share a common definition, perfectly compatible with this formalism, that indicate the influence of the respective charges on the medium and clearly illustrates the dimensional relationship between the flux and the field where the flux corresponds to the vector multiplication of the field with a surface, $\Phi = Es$. This is also true for the gravitic flux that shares a similar definition and relationship with the gravitic field, the acceleration. Consequently, the gravitic flux automatically corresponds to meters cubed divided by squared meters (m^3/s^2). Furthermore, the Gauss law for gravity confirms the role similarity between the gravitational constant G and the Coulomb's constant K. This implies that the gravitic flux can also be defined with respect to the medium $\Phi_G = 4\pi GM$, which becomes $\Phi_G = Q_G/\varepsilon_G$, because $\varepsilon_G = 1/4\pi G$ as will be shown in the section "Roles of the Dynamic group" of this document). The thermic Flux usually describes a heat flow between two points of different temperature. But as seen in the previous section, this role is already formally assumed by the thermic current, a flow of thermic charges. As the aim of generalization is to use a single term for a specific role, this study conceptually defines the thermic flux as a quantity corresponding to the thermic field multiplied by a surface ($\Phi_T = E_T s$). As the thermic field corresponds to the thermic potential (temperature) divided by a distance, the thermic flux unit will automatically become a quantity expressed in Kelvin times meters (K-m).

4.2. Potential

Following the definition of the flux, the potential represents the level of flux at some distance from the source. In other words, the potential is the linear measure (gradient) of the flux produced by the charge and dimensionally corresponds to the flux divided by a distance, $U = \Phi/d$, thus justifying the relationship between the Flux and the potential in the Radiation group. In an interaction situation (i.e. more than a single charge), the potential can also be defined as the effect of a current facing a resistance, $U = RI$. The known gravitic, electric and magnetic potentials are perfectly compatible with the given definition. Their relationships with their respective fluxes are easily demonstrated from the corresponding interaction force expressions (see Table 1). Considering the units of the gravitic field (m/s^2) and flux (m^3/s^2), the gravitic potential automatically becomes meter squared divided by second squared (m^2/s^2). The electric potential unit is arbitrarily set to Volts and the magnetic potential, also called the magnetomotive force, is known to be expressed in Amperes (A). The thermic potential also shares this definition and corresponds to the temperature expressed in Kelvins (K).

4.3. Field

A field is the spatial distribution of the flux produced by and surrounding a charge. In other words, the field shows the concentration of flux through a surface as demonstrated by the various versions of the gauss law illustrated in Table 4. From the dimensional point of view, the flux of these domains is always equal to the field times a surface ($\Phi = Es\cos\alpha$, α being the angle between the field and the surface, the cosines vector part being dimensionless). The field can then be defined from the initial flux, $E = \Phi/s$, or as the effect of a charge distribution opposed by the permittivity of the medium, $E = D/\varepsilon$. The gravitic, electric and magnetic fields share these definitions and are expressed in meter per second squared (m/s^2), volts per meter (V/m) and Tesla (T). The thermic field is easily conceived as a gradient of thermic potential, temperature, and will be expressed as Kelvin per meters (K/m).

5. Roles of the Static Group

The Static group quantifies the ability of the medium to oppose the conduction of energy either in time as a current, or in space as charge density. It represents the inverse of the Dynamic group with respect to roles, units and dimensions. The Static group elements along with their space time representation are presented in Fig. 6.

Quantity	Symbol	Relation
Resistivity	ρ	ρ
Resistance	R	ρ / d
Rigidity	K	ρ * t
Rigidance	Y	ρ * t / d

	R	**ρ**	
	Y	**K**	

Fig. 6. Static group elements

Considering their space-time only relationship which does not change the fundamental nature of the quantity, as soon as an element is found to be medium dependant, all other elements of both groups can also be said to be medium dependant. Consequently, as it is known that some of them are medium dependant, say Resistivity for example, all members of both groups are directly dependent on the medium involved and represent specific properties of this medium, which means that they cannot really be considered as "universal constants" or as "conversion parameters".

5.1. Resistivity and Resistance

Resistivity is a property of the medium indicating its opposition to the temporal conduction of charges as a current, while Resistance is, by definition, the measure of a level of resistivity per unit portion of the medium. The definition of resistivity is not related to the geometry of the location where a current is flowing, while the definition if Resistance explicitly integrates this geometry $\mathrm{R} = \rho/d$. Resistivity and resistance can also be deduced from the conduction process in which the resistance is the result of the division of a potential by the current it created $\mathrm{R} = U/I$. These concepts are well known in the electric and thermic domains where the resistance is respectively expressed in ohms (Ω) and Kelvin per Watt (K/W), and the resistivity in ohm meters (Ω-m) and Kelvin meters per Watt (K-m/W), confirming their dimensional relationship. A magnetic resistance, not to be confused with the Reluctance, would naturally result from the division of a magnetic potential expressed in Amperes (A) by a magnetic current expressed in Amperes meters per seconds (A-m/s) and thus be measured in second per meter (s/m). Even if it may appear at first like a strange concept, the gravitic resistance can nevertheless be easily understood if we consider the concepts presented in previous sections such as the gravitic potential (m^2/s^2), and current (kg/s), the gravitic resistance unit automatically becomes meters squared per kilogram seconds (m^2/kg-s).

5.2. Rigidity and Rigidance

Although appearing as a new concept, Rigidity is only the formalization of an existing role. It is a property of the medium whose unit, role and dimension are directly opposed to Permittivity. It is therefore the property that promotes radiation by the establishment of a flux as expressed by the Gauss law, $\Phi = Q/\varepsilon = 4\pi KQ$, and eventually, if a potential difference exists, the creation of an interaction force (see Table 1). The term rigidity is suggested because, as resistance, it implies an opposition to a conduction of energy. While the resistance opposes the temporal conduction called a current $I = U/R$, the rigidity opposes the spatial conduction called a charge distribution, $D = E/4\pi K$. The dimensional relationship between Rigidity and Resistance is implicitly demonstrated by the well known definition of the vacuum impedance $Z = 4\pi K/c$, as well as by the study of the units involved as illustrated by Table 5 which demonstrates that this relationship always corresponds to L/T (or m/s) as seen on the space-time matrix:

		Gravitic	Electric	Magnetic	Thermic
Flux	Φ	m^3s^{-2}	Vm	A-m	K-m
Potential	U	m^2s^{-2}	V	A	K
Charge	Q	Kg	C	A-m	K
Current	I	Kg/s	C/s	A-m/s	K/s
K/R	$\frac{\Phi/4\pi Q}{U/I}$	**m/s**	**m/s**	**m/s**	**m/s**

Table 5. The Resistance / Rigidity relationship

Rigidance is an already known [3] but rarely used quantity, the inverse of capacitance, which measures the amount of rigidity per unit portion of the medium. The definition of rigidance is intended to complete the normalization of the Static group by presenting a one to one relationship between each member of the Static group and its equivalent in the Dynamic group. As the Rigidity opposes the permittivity $\mathrm{K} = 1/4\pi\varepsilon$, the rigidance opposes the capacitance $Y = 1/4\pi C$. The electric domain calls rigidity the Coulomb's constant and it perfectly corresponds to the given definition. The magnetic rigidity can be directly derived from the magnetic interaction force equation and is equal to $\mu_0/4\pi$. Considering mass as a gravitic charge, it becomes obvious that, in the respective interaction force equations (see Table 1), the Coulomb and the Gravitational constants share an identical role in promoting the force.

5.3. Inductance and Permeability

As can be seen in the roles definition table, Inductance and Permeability are not included in standard roles. This is not necessary as these two quantities are only the mirror reflection of two already defined quantities: magnetic Permittivity and Capacitance. Electric and magnetic domains are known to be complementary in the sense that an energy variation in one of them implies an opposite variation in the other. This means that a quantity promoting energy conduction in one domain would oppose it in the other. Moreover, having defined the magnetic rigidity as $\mu/4\pi$, it becomes obvious that the permeability is the opposite of a quantity that corresponds to the magnetic permittivity $\mu = 1/\varepsilon_M$. Considering first the known relation between the vacuum impedance and permeability $Z_0 = \mu_0 c_0$, and also the fact that the magnetic permittivity belongs to the Magnetic Dynamic group, the permeability automatically falls into the Static group. All this reasoning is also true for the inductance which represents the opposite of the magnetic capacitance and whose relationship with the permeability is well known $\mu = L/d$. To summarize, permeability and inductance are two electric domain quantities that represent two quantities of the magnetic domain, the magnetic permittivity and capacitance $C_M = 1/L$ and $\varepsilon_M = 1/\mu$. This is equivalent to considering inductance as proportional to the amount of stored magnetic charge, the same way capacitance is proportional to the amount of stored electric charge. It follows that the traditional magnetic rule $B = \mu H$ becomes identical to its electric counterpart $B = H/\varepsilon_M \Leftrightarrow E = D/\varepsilon_M$, and this highlight the fact that H and D play the same role of a charge distribution.

6. Roles of the Dynamic Group

The Dynamic group contains elements that promote the conduction of energy and represents the inverse of the Static group. Fig. 7 presents the members of the dynamic group as well as their space-time representation:

Quantity	Symbol	Relation
Conductivity	σ	G / d
Conductance	G	G (=1 / R)
Permittivity	ε	1 / (4π K)
Capacitance	C	ε * d

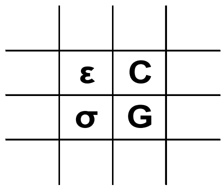

Fig. 7. Dynamic group elements

As quantities of the Static and Dynamic groups are in perfect opposition with respect to their roles, units and dimensions. The demonstration of their relationships provided in the previous section can be reversed and directly applied to all members of the Dynamic group. This fact justifies their presence in the Dynamic group, as well as their position on the space-time matrix. This also means that as soon as one of these eight elements is defined, all other elements of the Static and Dynamic groups are also defined.

6.1. Conductivity and Conductance

Conductivity is the quantity directly opposed to Resistivity and represents the ability of the medium to promote the flow of charges called a current. Conductance, opposed to Resistance, represents the promotion of a unit portion of the medium to a current $I = GU$. These concepts are well known in the electric and thermic domains where Conductance is respectively expressed in Siemens (S) and Watts per Kelvins (W/K). The magnetic conductivity (1/s) and conductance (m/s) naturally oppose the magnetic resistivity and resistance. This is also true for the gravitic conductivity (kg-s/m^3) and conductance (kg-s/m^2).

6.2. Permittivity and Capacitance

Permittivity, the opposite of Rigidity, is defined as the property of the medium promoting spatial conduction of energy under the form of a charge distribution $D = \varepsilon E$, or equivalently opposing the radiation under the form of a field $E = D/\varepsilon$.

Capacitance is the promotion of a unit portion of the medium to spatial diffusion ($Q = CU$), and is opposed to Rigidance ($C = 1/4\pi Y$) while Permittivity is directly opposed to Rigidity ($\varepsilon = 1/4\pi K$).

7. Standard Domain Operations

The generalization of domains, groups and roles can glimpse at the common internal organization of a standard domain. The four groups form a coherent entity whose internal operating mechanism is illustrated by Fig. 8.

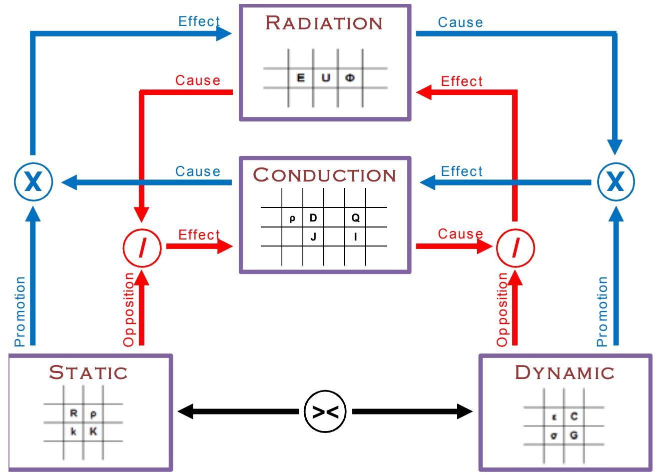

Fig. 8. Standard domain operations

Fig. 8 shows a view of the internal structure and mechanism of every standard domain in the context of the proposal "effect = cause / opposition" or its corollary "effect = cause * promotion". All interactions between elements of any standard domain are represented in this diagram. The symbol "><" corresponds to the inverse proportionality between the Static and Dynamic groups, meaning that to each element of the Static group is associated an element of the Dynamic group whose role, dimension and unit are in perfect opposition. The four main branches illustrate the universal cause and effect principle with respect to standard domains organization. Table 6 summarizes all interaction combinations illustrated by the "X" and "/" branches

	Described phenomenon (nature of the effect)	
	Radiation	Conduction
Effect = Cause / Opposition	**Right /**	**Left /**
Effect = Cause * Promotion	**Left X**	**Right X**

Table 6. Standard domain operations

It now becomes easy to expect a complete generalization of all equations associated with standard domains. Note that in connection with the concept of cause and effect presented above, we see that for all equation describing the operation of a domain, the elements of the Radiation and Conduction groups can be either the cause or effect described by the equation, while elements of the static and dynamic groups can only represent a promotion or an opposition.

8. The Energetic Domain

The Energetic domain contains elements that represent the various aspects of energy radiation or conduction resulting from physical interactions in any standard domain. The elements of the energetic domain and their space-time representation are presented in Fig. 9.

Quantity	Symbol	Relation
Energy	N	N
Force	F	N / d
Power	P	N / t
Action	A	N * t
Momentum	M	N * t / d
Eflux	X	N * d

	M	A		
	F	N	X	
		P		

Fig. 9. Energetic domain elements

The concepts associated with energy are only relevant in the context of an interaction between different elements. For a universe composed of a single particle, potential or kinetic energy would be meaningless since the first corresponds to the position of a particle in an already existing field necessarily created by another particle, while the second corresponds to the energy expended in moving the charge in such a field.

8.1. Potential and Kinetic Energy

Potential energy is proportional to the amount of stress created by placing a charge in an already existing field. This stress is measured as a potential difference and there is a natural tendency to reduce and suppress any potential difference as soon as it occurs in any standard domain. The energy accumulated because of the existence of this potential difference, called the potential energy, becomes a force acting over the (squared) distance separating the two charges and whose only role is to destroy this difference. For example, in the gravitic domain, as soon as a mass, the gravitic charge, increases its potential by being lifted, the accumulated potential energy will be expressed as a force leading the mass to a position of lesser potential, in this case, the ground. As this definition is of course valid for all standard domains, potential energy can generically be said to correspond to the amount of charge times the potential difference it experiences ($N_P = QU$). The definitions of the energetic domain quantities are traditionally derived from the gravitic domain thus, the Joule is usually defined as kilograms times meters squared per second squared (kg-m^2/s^2). It may seem strange to use elements of the gravitic domain when calculating energy quantities related to electricity, magnetism or thermodynamics. The energy stored in a capacitor or an inductor has nothing to do with mass or acceleration that respectively represent the gravitic charge and field. In fact, all energetic domain quantities can actually be calculated from the combination of quantities of each standard domain, thereby generalizing the definition of these quantities. The potential energy of a charge can thus be equally derived from any standard domain and the Joule can be considered as the multiplication of the charge unit with the unit of the potential of any standard domain as illustrated by Table 7.

Domain	Equation	Unit
Generic	$N_P = Q * U$	Joule
Gravitic	$N_P = M_1 * GM_2/r$	kg-m^2 / s^2
Electric	$N_P = Q_1 * KQ_2/r$	C-V
Magnetic	$N_P = I * d * A$	A^2-m
Thermic	$N_P = Kb * T$	K-K

Table 7. Joule unit definition

All these expressions of the Joule are perfectly equivalent and the same reasoning applies for all elements of the Energetic domain.

Kinetic energy corresponds to the energy used by a charge to respond to an imposed force. This imposed force can be artificial as in most existing contact forces, but it can also be natural as the interaction force automatically created to overcome a potential difference. Potential and kinetic energy share the same definition regarding dimensions and units. They are consequently presented in the same cell of the space time matrix and use a unique symbol with two indices, respectively, N_P and N_K.

8.2. Force

Force is basically the spatial linear distribution of energy and the unit of force, the Newton (N), naturally corresponds to Joules per meters (J/m). However, force and its unit can be defined from any standard domain as the multiplication of the amount of charge by the field it experiences as illustrated by Table 8.

Domain	Equation	Unit
Generic	F = Q * E	Newton
Gravitic	F = m * a	kg-m / s^2
Electric	F = Q * E	C-V / m
Magnetic	F = I * d * B	A-m * T
Thermic	F = K * T / d	K-K / m

Table 8. Newton unit definition

8.3. Power

Power is literally a flow of energy $P = N/t$, and results from the multiplication of a potential by the current it created ($P = UI$). This definition is true for all standard domains and Table 9 illustrates the different definitions of the power unit, the Watt.

Domain	Equation	Unit
Generic	P = I * U	Watt
Gravitic	P = Φ * V	Kg-m^2 / s^3
Electric	P = I * U	A-V
Magnetic	P = (I * d / s) * A	A^2-m / s
Thermic	P = Φ * T	K-K / s

Table 9. Power unit definition

9. Meta-equations

Considering the organizational structure just presented, it is now possible to perform a complete generalization of the equations describing the behavior of physical quantities. The following table presents the fundamental Meta-equations from which all known physical equations can be generated:

Space-time relationships

STE = STE op STE
EDE = EDE op STE
GRX = GRX op STE

Static and Dynamic groups relationships

GST	=	1	/	GDY
GDY	=	1	/	GST

Standard domain operations relationships

GCO	=	GRA	/	GST
GCO	=	GRA	*	GDY
GRA	=	GCO	/	GDY
GRA	=	GCO	*	GST
GST	=	GRA	/	GCO
GDY	=	GCO	/	GRA

Energy radiation or conduction relationships

EDE	=	GRA	*	GCO
GCO	=	EDE	/	GRA
GRA	=	EDE	/	GCO

The corresponding legend is as follows:

op Operator * or /
STE An element of the Space-Time domain
EDE An element of the Energetic domain
GRX An element of any group of a standard domain
GRA An element of the Radiation group
GCO An element of the Conduction group
GST An element of the Static group
GDY An element of the Dynamic group

9.1. Space-time Relationships

The three first meta-equations describe all possible combinations of the spatiotemporal relationships between physical quantities according to Table 10.

Meta-equation	Scope	Examples	
STE = STE op STE	SpaceTime domain	$c=d/t$	
EDE = EDE op STE	Energetic domain	$P=N/t$	$F=N/d$
GRX = GRX op STE	A member of a group of a standard domain	$I=Q/t$ $E=U/d$ $R=\rho/d$ $C=\varepsilon*d$	Conduction Radiation Static Dynamic

Table 10. Space-time relationships

9.2. Static and Dynamic Group Relationships

As previously stated, the Static and Dynamic groups are in perfect inversion with respect to roles, units and dimensions. This is reflected in the associated meta-equations in Table 11:

Meta-equation	Examples	
GST = 1 / GDY	$R=1/G$	$\mathrm{K}=1/4\pi\varepsilon$
GDY = 1 / GST	$G=1/R$	$\varepsilon=1/4\pi K$

Table 11. Static and Dynamic groups relationships

9.3. Standard Domain Operations Relationships

This section describes all relationships between members of a standard domain and, in addition with the Static and Dynamic groups relationships described in the previous section, it completely represents the standard domain operational structure according to the cause and effect principle as shown in Table 12:

Meta-equation	Examples	
GCO = GRA / GST	$I=U/R$	$Q=\Phi/4\pi K$
GCO = GRA * GDY	$I=UG$	$Q=\Phi\varepsilon$
GRA = GCO * GST	$U=IR$	$\Phi=4\pi KQ$
GRA = GCO / GDY	$U=I/G$	$\Phi=Q/\varepsilon$
GST = GRA / GCO	$R=U/I$	$4\pi K=\Phi/Q$
GDY = GCO / GRA	$G=I/U$	$\varepsilon=Q/\Phi$

Table 12. Standard domain operations relationships

9.4. Energy Radiation or Conduction Relationships

This section describes relationships related to the energetic domain elements, according to Table 13.

Meta-equation	Examples			
EDE = GRA * GCO	$P=UI$	$N=UQ$	$F=EQ$	$X=\Phi Q$
GRA = EDE / GCO	$U=P/I$	$U=N/Q$	$E=F/Q$	$\Phi=X/Q$
GCO = EDE / GRA	$I=P/U$	$Q=N/U$	$Q=F/E$	$Q=X/\Phi$

Table 13. Energy radiation or conduction relationships

10. Conclusion

The proposed formalism normalized the definitions of physical quantities in a coherent structure that highlighted the complete similarity in the operating mechanism of the various domains of physics. This allowed the full generalization of all equations governing their behavior and a new understanding of the specific influence of each quantity in the mathematical description of reality.

References

[1] Lon Edward Bell, "Energy Transport by Combined Radiation and Conduction", Thesis, pp. 17-58 (California Institute of Technology, 1969), http://thesis.library.caltech.edu/1136/1/Bell_le_1968.pdf.

[2] Oliver Heaviside, "A Gravitational and Electromagnetic Analogy, Part I", *The Electrician* **31**: 281-282 (1893), http://www.wbabin.net/historical/heaviside.pdf.

[3] James Ives, "Rigidance, a new name for the Reciprocal of Capacity", *Electrical World and Engineer* **44**: 248 (1904).