Maxwell's Electromagnetic Equations Reinterpreted in Mechanical Terms

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Using dimensionality, as shown in previous published papers, many of the standard equations of electromagnetism can be stated instead in terms of mechanical parameters and equations. This enables a reinterpretation of what standard electromagnetic properties or parameters actually represent.

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I. WHY A REINTERPRETATION IS NEEDED

The electromagnetic parameters may be better understood now than when first discovered, but they remain difficult to understand when compared with the more simple mechanical parameters. What, for example, does the Electric Field Displacement D actually displace? And why do B and H have different SI units? The latter is explained in earlier work [1,2], but the former has not been considered in the same way before.

This paper sets out to show what the most likely reinterpretations of the main electromagnetic parameters and equations in terms of mechanical parameters and equations are in the expectation that deeper understanding will emerge.

II. ELECTROMAGNETICS INTO MECHANICS

The starting point is to state the standard mechanical and electromagnetic properties or parameters in terms of their dimensionalities. Then some of the standard equations of electromagnetism will be reinterpreted as mechanical equations, together with how the two types of property or parameter can be related.

Note that no directionality will be considered, in terms of cross or dot products, and constants will be ignored where they have zero dimensionality.

There are also some additional parameter names which are used historically and need to have dimensionalities shown that are included after the main list.

The foundation of the analysis is the use of the charge-mass qc rather than q as the unit of electromagnetism, so that the mechanical unit m and the electromagnetic unit qc have the same dimensionality of Y^1 [1].

Parameter	Symbol	Dimensionality
Gravitational Constant	G	Y^0
Permeability	u	Y^0
Boltzmann's Constant	k_B	Y^0
Angular Momentum	h	Y^0
Mass	m	Y^1
Magnetic Flux	φ	Y^1
Charge-mass	qc	Y^1
Velocity	v	Y^2
Resistance	R	Y^2
Momentum	mv	Y^3
Current	I	Y^4
Action	m/L	Y^4
Angular Frequency	w	Y^5
Frequency	f	Y^5
Energy	E	Y^5
Temperature	K	Y^5
Potential Difference	V	Y^6
Acceleration	a	Y^7
Magnetic Inductance	B	Y^7
Magnetic Field	H	Y^7

Force	F	Y^{8}
Electric Field	ξ	Y^{9}
Viscosity	η	Y^{9}
Mass Density	ρ	Y^{10}
Current Density	J	Y^{10}
Power	P	Y^{10}
Pressure	p	Y^{14}
Energy Density	ϵ	Y^{14}
Charge	q	Y^{-1}
Conductance	ς	Y^{2}
Moment	mL	Y^{-2}
Distance	L	Y^{-3}
Inductance	$\mathcal{L}$	Y^{-3}
Permittivity	ε	Y^{-4}
Time	T	Y^{-5}
Area	A	Y^{-6}
Volume	V	Y^{-9}
Vector potential (usually 'A')	Ш	Y^{4}
Gradient operator (del)	∇	Y^{-3}
Displacement Field	D	Y^{5}
Electric charge density	σ	Y^{8}
Electric Potential	∀	Y^{6}

Note that some of the additional parameters are the same as those on the main list, but are listed separately because they are generally used with different symbols. So electric potential ∀ is the same as potential difference ∨, but the former is used more commonly.

Using the simplified SI differential equations for Gauss, Maxwell- Faraday and Ampere's laws as

$$\nabla.\xi = \sigma/\varepsilon$$
$$\nabla.B = 0$$
$$\nabla\text{x}\xi = dB/dT$$
$$\nabla\text{x}B = u(J + \varepsilon\, d\xi/dT)$$

and the Lorenz force equation of

$$F = q\xi + qv\,\text{x}\,B$$

as a simple intermediate step, these equations can be rearranged into mechanical properties as follows:

$$F = q\xi + qv\,\text{x}\,B = (qc)\left(\frac{\xi}{c}\right) + (qc)v(\frac{B}{c})$$

Since qc has been defined as equivalent to mass m, then ξ/c must be acceleration in the first part of the equation. This equates dimensionally ξ/c as acceleration a with dimensionality Y^7. Treating qc as equivalent to mass m again in the second part equates B/c to energy E with dimensionality Y^5 in the second.

The equation in mechanical terms now states

$$F = m\left(\frac{\xi}{c}\right) + (qc)v\left(\frac{B}{c}\right) = ma + mvE$$

To simplify overly, for clarity of dimensional implication only, if the system under consideration were compared to an orbiting particle with angular momentum $h = mvL$, then the equation would become

$$F = ma + hE/L$$

which suggest that the force is due partly to the acceleration of the charge-mass and partly to the potential energy of the system, which is what would be expected for an orbiting particle system.

1) Analysing the laws above in the same way for

$$\nabla.\xi = \sigma/\varepsilon$$

but substituting $\nabla = 1/\text{L}$, $\varepsilon = c^{-2}$ and $\xi c^{-2} = E$ for dimensionality reasons arrives at

$$\xi/L = \sigma/\varepsilon$$

or, since σ = F dimensionally, then

$$\xi c^{-2}/L = E/L = F$$

which is the same as seen already in the force equation, stating that the energy of a system at some distance is a force.

2) For $\nabla.B = 0$

with $Bc^{-1} = E$ becomes

$$E/L = 0$$

which states that the system has no relevant energy, which is the case since the region for this equation has no charges and no currents

3) For $\nabla\text{x}\xi = dB/dT$

the substitutions $\xi c^{-1} = a$ and $Bc^{-1} = E$ give

$$\xi c^{-1}/L = a/L = Bc^{-1}/T = E/T = P$$

Since power P has dimensionality Y^{10} this equation, adjusted by c, states the power of the system.

There are other equations that can be recast in mechanical terms

4) $\nabla\text{x}B = \varepsilon d\xi/dT$

giving

$$Bc^{-1}/L = c^{-2}\xi c^{-1}/T$$

or

$$E/L = c^{-2}a/T = F$$

This equation, adjusted by c, states the force in action of the system.

5) For $B = \nabla \times Ш$

the reinterpretation gives

$$Bc^{-1} = Шc^{-1}/L = E$$

This equation, adjusted by c, states the energy of the system.

6) For $\xi = -\nabla\forall - dШ/dT$

rearrangement gives

$$\xi c^{-1} = -\forall c^{-1}/L - Шc^{-1}/T$$

or, again using overly simplistic particle rotation analogies where $h = mvL, v = rw, T = 2\pi/w$ and $Шc^{-1} = v$, this equation can be recast mechanically as

$$a = -hc^{-1}/(2\pi L^3) - v/T$$

This equation, adjusted by c, states the acceleration of the system.

7) For $\nabla . Ш = -c^{-2}d\forall/dT$

this gives, using the same overly simplistic analogies,

$$Шc^{-1}/\mathrm{L} = -c^{-3}h/(2\pi L^2 T)$$

or

$$v/\mathrm{L} = -c^{-3}h/(2\pi L^2 T) = E$$

This equation, adjusted by c, states the energy of the system.

8) For $0 = \nabla . \nabla \mathrm{x} B = u(\nabla . \mathrm{J} + d\sigma/dT)$

rearranging, ignoring the dimensionless constant u, and using $\mathrm{J}c^{-1} = F$, $\sigma c^{-1} = \forall$ and the same overly simplistic relationships, gives

$$0 = Bc^{-1}/L^2 = \mathrm{J}c^{-1}/L + \sigma c^{-1}/T$$

or

$$0 = E/L^2 = F/L + h/(2\pi L^2 T)$$

or

$$0 = E = FL + h/(2\pi T)$$

This equation, which in its normal form represents the conservation of charge, here, as adjusted by c and L, states the energy of the system is zero. Moreover it says that in a rotating system such as used here, the energy of rotation is equal and opposite to the force at a distance from the centre of rotation.

9) For $\nabla . D = \sigma$

with $D = E$ this becomes

$$\frac{E}{L} = \sigma = F$$

This equation states the force acting within the system.

What can be inferred from the above reinterpretations is that the following electromagnetic parameters can be interchanged with mechanical ones, when adjusted by c:

EM Parameter >>	**Mechanical Parameter**
$qc = m$	Mass
$\phi = m$	Mass
$R = v$	Velocity
(which electrons must exceed in order to flow)	
$Шc^{-1} = v$	Velocity
$\xi/c = a$	Acceleration
$B/c = E$	Energy
$\mathrm{D} = E$	Energy
$c^{-3}d\forall/dT = E$	Energy
$Шc^{-1}/L = E$	Energy
$\mathrm{J}c^{-1} = F$	Force
$\sigma = F$	Force
$\vee c = F$	Force
$\forall c = F$	Force
$dB/cdT = P$	Power

These reinterpretations should not be taken as providing exact equations for mechanical systems.

This can be achieved by using the electromagnetic equations precisely, in the correct context, and with a particle mass equal in size to the charge-mass, although the charge-mass interactions will additionally provide attraction and repulsion of charges, rather than just mass attraction. Also the directions of forces will not mirror mass-only equations. The parameters used here, when calculated in DAPU units at their maximal electron-charge based DAPU values, will be correct, but will say nothing about intermediate values.

This analysis has been simplified to show that electromagnetic parameters and equations are interchangeable, with care, and to enable a different interpretation of what the electromagnetic parameters, as adjusted by c , mean mechanically.

III. CONCLUSION

The electromagnetic parameters can be successfully displayed as mechanical, with corresponding equations. The Electric Field Displacement D actually represents the energy of the system.

III. REFERENCES

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