On the analysis of two Maxwell's equations: possible mathematical connections with some sectors of Number Theory.

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Abstract

In this paper, we analyze two Maxwell's equations and describe the possible mathematical connections with some sectors of Number Theory.

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The Maxwell's equations in differential and integral form are:

$$\nabla \cdot \vec{E} = \frac{\rho}{\varepsilon_0} = 4\pi k\rho \qquad \oint \vec{E} \cdot d\vec{A} = \frac{q}{\varepsilon_0}$$

$$\nabla \cdot \vec{B} = 0 \qquad \oint \vec{B} \cdot d\vec{A} = 0$$

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} \qquad \oint \vec{E} \cdot d\vec{s} = -\frac{d\Phi_B}{dt}$$

$$\nabla \times \vec{B} = \frac{\vec{J}}{\varepsilon_0 c^2} + \frac{1}{c^2}\frac{\partial \vec{E}}{\partial t} \qquad \oint \vec{B} \cdot d\vec{s} = \mu_0 i + \frac{1}{c^2}\frac{\partial}{\partial t}\int \vec{E} \cdot d\vec{A}$$

We analyze the I and IV equation in integral form, i.e. the equation concerning the Gauss' law for electricity and the equation concerning the Ampere's law.

$$\oint \vec{E} \cdot d\vec{A} = \frac{q}{\varepsilon_0}$$

Integral form

$$\oint \vec{E} \cdot d\vec{A} = \frac{q}{\varepsilon_0} = 4\pi kq$$

Differential form

$$\nabla \cdot E = \frac{\rho}{\varepsilon_0} = 4\pi k\rho$$

(4Pi*8.987552*10^9*1.602176634*10^-19)

We know that:

$$k = \frac{1}{4\pi\varepsilon_0} \qquad c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$$

where

$$k = \frac{1}{4\pi\varepsilon_0} = 8.987552 \times 10^9\, Nm^2 \;/\; C^2$$ = Coulomb's constant

With regard

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 i + \frac{1}{c^2} \frac{\partial}{\partial t} \int \vec{E} \cdot d\vec{A}$$

we have:

⊕ proton charge e = 1.602 x 10^{-19} coulombs

⊖ electron charge -e = -1.602 x 10^{-19} coulombs

and

$$\varepsilon_0 = 8.854187817 \times 10^{-12}\, F \,/\, m \approx 8.85 \times 10^{-12}\, F \,/\, m$$

that is the value of the free space electric permittivity

$$\mu_0 = 4\pi \times 10^{-7}\, N \,/\, A^2$$

that is the value of the magnetic permeability of free space

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$$

that is the speed of light:

$$c = 2.99792458 \times 10^8\, m\,/s(exact) \approx 3 \times 10^8\, m \,/\, s$$

Electric Current Formula By Definition

By definition electric current is defined as the rate of flow of charge. We know that 1 Ampere is the current in circuit when 1 coulomb of charge passes through a given point in one second.

Mathematically

$$I(\text{amperes}) = \frac{Q(\text{coulombs})}{t(\text{seconds})}$$

where

I = current in amperes ; Q = charge in coulombs ; t = time in seconds

Electric charge $1.602176634 \times 10^{-19}$ C

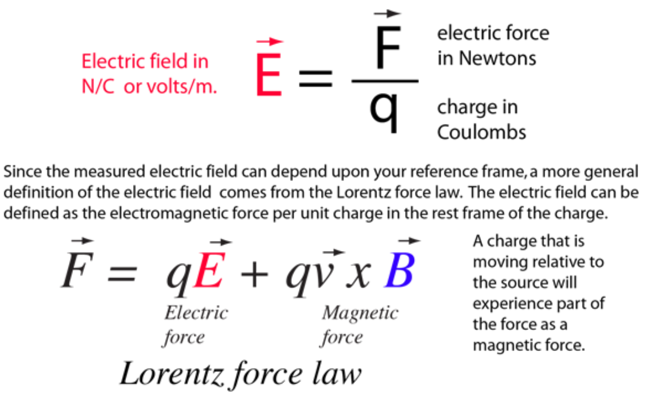
From the equation of the Ampere's law:

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 i + \frac{1}{c^2} \frac{\partial}{\partial t} \int \vec{E} \cdot d\vec{A}$$

Integrate(B*ds)

Indefinite integral

$$\int B\, ds = B\, s + \text{constant}$$



We know that using Coulomb's law and values of Q_1, Q_2, and d, the electric force can be found to be **5.64×10^{-3} N**.

For:

μ_0= (4Pi*10^-7) ; i = Q/t , where we have considered Q = $1.602176634\times10^{-19}$ C ; c = 299792458 (speed of light) and electric force e = $5.64*10^{-3}$ (from the above formula E = F / q), we obtain:

(4Pi*10^-7)*(1.602176634*10^-19)/t+1/(2.99792458*10^8)^2*partial derivative t*integrate(5.64*10^-3/(1.602176634*10^-19))dA

Input interpretation

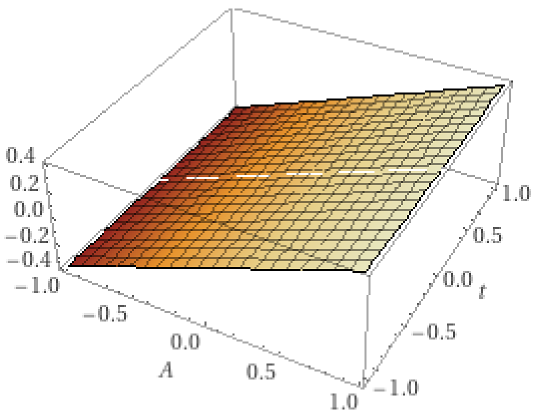
$$\frac{4\pi}{10^7}\times\frac{1.602176634\times10^{-19}}{t}+\frac{1}{(2.99792458\times10^8)^2}\,t'(t)\int\frac{5.64\times10^{-3}}{1.602176634\times10^{-19}}\,dA$$

Result

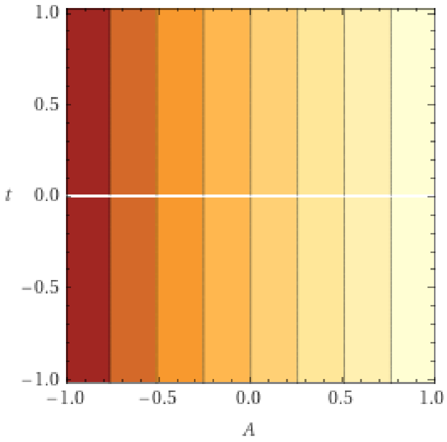
$$0.391676\,A+\frac{2.01335\times10^{-25}}{t}$$

The study of this function provides the following representations:

3D plot



Contour plot



Alternate forms

$$\frac{0.391676\,A\,t + 2.01335\times10^{-25}}{t}$$

$$\frac{0.391676\left(A\,t + 5.14035\times10^{-25}\right)}{t}$$

Alternate form assuming A and t are real

$$0.391676\,A + \frac{2.01335\times10^{-25}}{t} + 0$$

Derivative

$$\frac{\partial}{\partial t}\left(0.391676\,A + \frac{2.01335\times10^{-25}}{t}\right) = -\frac{2.01335\times10^{-25}}{t^2}$$

Indefinite integral assuming all variables are real

$$0.391676\,A\,t + 2.01335\times10^{-25}\log(t) + \text{constant}$$

From the result of:

$$\frac{\partial}{\partial t}\left(0.391676\,A + \frac{2.01335\times 10^{-25}}{t}\right) = -\frac{2.01335\times 10^{-25}}{t^2}$$

for t = 1, and the value of the electric force e = $5.64*10^{-3}$, we obtain also:

sqrt(((2.01335*10^-25)/(5.64*10^-3)))*(((log^4(2) log^2(3))/(sqrt(6) e)))

where

$$\frac{\log^4(2)\log^2(3)}{\sqrt{6}\,e}$$

is equal to 0.04184279071722669…..

Input interpretation

$$\sqrt{\frac{2.01335\times 10^{-25}}{5.64\times 10^{-3}}}\times\frac{\log^4(2)\log^2(3)}{\sqrt{6}\,e}$$

log(x) is the natural logarithm

Result

$2.50000\ldots\times 10^{-13}$

$2.5*10^{-13}$

Thence, from:

$$0.391676\,A + \frac{2.01335\times 10^{-25}}{t}$$

i.e.

0.391676 A + 2.01335*10^-25/t

for: A = 2.5*10^-13

we obtain, after some calculations:

[((1/((((0.391676 *2.5*10^-13 + (2.01335×10^-25)))))*((1/299792458))))]^1/21

where 299792458 = c is the speed of light

Input interpretation

$$\sqrt[21]{\frac{1}{0.391676\times 2.5\times 10^{-13}+2.01335\times 10^{-25}}\times\frac{1}{299792458}}$$

Result

1.643707…

1.643707….≈ ζ(2) = $\frac{\pi^2}{6}$ = 1.644934 ... (trace of the instanton shape)

We obtain also:

((0.391676*2.5*10^-13)+(2.01335*10^-25)/(5.391*10^-44))

Input interpretation

$$0.391676\times 2.5\times 10^{-13}+\frac{2.01335\times 10^{-25}}{5.391\times 10^{-44}}$$

Result

3.734650343164533481728807271378320883199591912446670376553 51… × 10^{18}

3.73465034316…*10^{18}

From which:

((0.391676*2.5*10^-13)+(2.01335*10^-25)/(5.391*10^-44))*((log^5(3))/(9 e^2))

where 5.391*10^{-44} is the Planck time and

$$\frac{\log^5(3)}{9\,e^2}\approx 0.02406527282$$

Input interpretation

$$\left(0.391676\times 2.5\times 10^{-13}+\frac{2.01335\times 10^{-25}}{5.391\times 10^{-44}}\right)\times\frac{\log^5(3)}{9\,e^2}$$

log(x) is the natural logarithm

Result

$8.98754\ldots\times 10^{16}$

$8.98754*10^{16}\approx c^2$ = the square of speed of light

We have:

$$\oint \vec{E}\cdot d\vec{A}=\frac{q}{\varepsilon_0}$$

For:

$$\varepsilon_0=8.854187817\times 10^{-12}\,F/m\approx 8.85\times 10^{-12}\,F/m$$

Electric charge = $1.602176634\times 10^{-19}$ C

q/ε_0 = (1.602176634×10^-19 / 8.854187817*10^-12)

from:

$$\oint \vec{B}\cdot d\vec{s}=\mu_0 i+\frac{1}{c^2}\frac{\partial}{\partial t}\int \vec{E}\cdot d\vec{A}$$

we obtain:

4Pi*10^-7*1.602176634*10^-19/t+(derivative(c^-2)t)(1.602176634×10^-19 / 8.854187817*10^-12)

Input interpretation

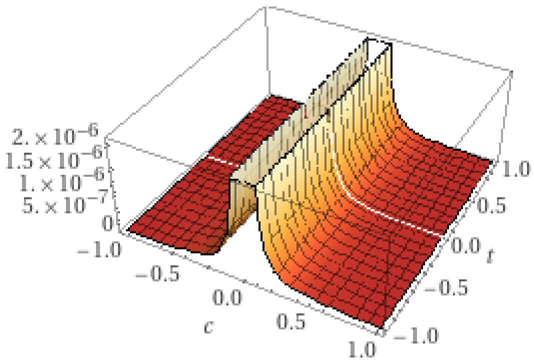
$$\frac{4\pi\times\frac{1.602176634\times 10^{-19}}{t}}{10^7}+\frac{\partial}{\partial t}\frac{t}{c^2}\times\frac{1.602176634\times 10^{-19}}{8.854187817\times 10^{-12}}$$

Result

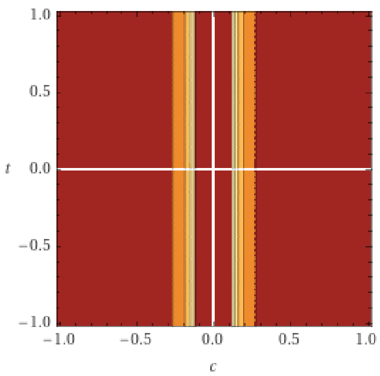
$$\frac{1.80951 \times 10^{-8}}{c^2} + \frac{2.01335 \times 10^{-25}}{t}$$

The study of this function provides the following representations:

3D plot



Contour plot



Alternate form

$$\frac{2.01335 \times 10^{-25}\, c^2 + 1.80951 \times 10^{-8}\, t}{c^2\, t}$$

Root

$t \approx -1.11265 \times 10^{-17}\, c^2, \quad c \neq 0$

Integer roots

$c = -4\,135\,718\,033\,067\,117\,830\,851\,241\,880\,(12\,n - 1)$,
$t = -190\,309\,486\,415\,173\,312\,896\,829\,993\,575\,044\,535\,310\left(144\,n^2 - 24\,n + 1\right)$,
$n \in \mathbb{Z}, \quad n \geq 1$

$c = -8\,271\,436\,066\,134\,235\,661\,702\,483\,760\,(6\,n - 1)$,
$t = -761\,237\,945\,660\,693\,251\,587\,319\,974\,300\,178\,141\,240\left(36\,n^2 - 12\,n + 1\right)$,
$n \in \mathbb{Z}, \quad n \geq 1$

$c = -12\,407\,154\,099\,201\,353\,492\,553\,725\,640\,(4\,n - 1)$,
$t = -1\,712\,785\,377\,736\,559\,816\,071\,469\,942\,175\,400\,817\,790\left(16\,n^2 - 8\,n + 1\right)$,
$n \in \mathbb{Z}, \quad n \geq 1$

$c = -16\,542\,872\,132\,268\,471\,323\,404\,967\,520\,(3\,n - 1)$,
$t = -3\,044\,951\,782\,642\,773\,006\,349\,279\,897\,200\,712\,564\,960\left(9\,n^2 - 6\,n + 1\right)$,
$n \in \mathbb{Z}, \quad n \geq 1$

$c = -4\,135\,718\,033\,067\,117\,830\,851\,241\,880\,(12\,n - 5), \quad t =$
$-190\,309\,486\,415\,173\,312\,896\,829\,993\,575\,044\,535\,310\left(144\,n^2 - 120\,n + 25\right)$,
$n \in \mathbb{Z}, \quad n \geq 1$

$\mathbb{Z}$ is the set of integers

Properties as a real function

Domain

$\{t \in \mathbb{R} : t \neq 0\}$

Range

$\{y \in \mathbb{R} : c \neq 0 \text{ and } 100\,000\,000\,000\,000\,000\,000\,000\,c^2\,y \neq 1\,809\,512\,817\,114\,437\}$

$\mathbb{R}$ is the set of real numbers

Derivative

$$\frac{\partial}{\partial t}\left(\frac{1.80951\times10^{-8}}{c^2}+\frac{2.01335\times10^{-25}}{t}\right)=-\frac{2.01335\times10^{-25}}{t^2}$$

Indefinite integral

$$\int\left(\frac{1.80951\times10^{-8}}{c^2}+\frac{2.01335\times10^{-25}}{t}\right)dt=$$
$$\frac{1.80951\times10^{-8}\,t}{c^2}+2.01335\times10^{-25}\log(t)+\text{constant}$$

(assuming a complex-valued logarithm)

$\log(x)$ is the natural logarithm

Limit

$$\lim_{t\to\pm\infty}\left(\frac{1.80951\times10^{-8}}{c^2}+\frac{2.01335\times10^{-25}}{t}\right)=\frac{1.80951\times10^{-8}}{c^2}$$

From:

$$\frac{1.80951\times10^{-8}}{c^2}+\frac{2.01335\times10^{-25}}{t}$$

we obtain:

(1.80951×10^-8)/(299792458)^2 + (2.01335×10^-25)/(5.319*10^-44)

where $5.319*10^{-44}$ = Planck time (International Gaussian system value)

Input interpretation

$$\frac{1.80951\times10^{-8}}{299\,792\,458^2}+\frac{2.01335\times10^{-25}}{5.319\times10^{-44}}$$

Result

$3.7852039857115999247978943410415491633765747454223747355 2270\ldots \times 10^{18}$

3.7852039857….*10^{18}

Or:

(1.80951×10^-8)/(299792458)^2 + (2.01335×10^-25)/(1.911147*10^-43)

where 1.911147*10^{-43} = Planck time (Lorentz-Heaviside value)

Input interpretation

$$\frac{1.80951\times 10^{-8}}{299\,792\,458^2}+\frac{2.01335\times 10^{-25}}{1.911147\times 10^{-43}}$$

Result

$1.0534773096993585527434572013560443021913020739802063187 5328\ldots \times 10^{18}$

1.0534773096…*10^{18}

Now, dividing the two previous expressions, i.e.

$$0.391676\times 2.5\times 10^{-13}+\frac{2.01335\times 10^{-25}}{5.391\times 10^{-44}}$$

and

$$\frac{1.80951\times 10^{-8}}{299\,792\,458^2}+\frac{2.01335\times 10^{-25}}{1.911147\times 10^{-43}}$$

we obtain:

(((((0.391676*2.5*10^-13)+(2.01335*10^-25)/(5.391*10^-44))))) / ((((1.80951×10^-8)/(299792458)^2 + (2.01335×10^-25)/(1.911147*10^-43))))

Input interpretation

$$\frac{0.391676 \times 2.5 \times 10^{-13} + \frac{2.01335 \times 10^{-25}}{5.391 \times 10^{-44}}}{\frac{1.80951 \times 10^{-8}}{299792458^2} + \frac{2.01335 \times 10^{-25}}{1.911147 \times 10^{-43}}}$$

Result

3.545069560378408458542014468558801907747907279221760366633963 8858
…

3.54506956037….

Or:

1/((((((1.80951×10^-8)/(299792458)^2 + (2.01335×10^-25)/(1.911147*10^-43))))1/(((((0.391676*2.5*10^-13)+(2.01335*10^-25)/(5.391*10^-44)))))))

where multiplying

$$\frac{1.80951 \times 10^{-8}}{299792458^2} + \frac{2.01335 \times 10^{-25}}{1.911147 \times 10^{-43}}$$

by the inverse of

$$0.391676 \times 2.5 \times 10^{-13} + \frac{2.01335 \times 10^{-25}}{5.391 \times 10^{-44}}$$

and inverting all, we obtain:

Input interpretation

$$\frac{1}{\left(\frac{1.80951 \times 10^{-8}}{299792458^2} + \frac{2.01335 \times 10^{-25}}{1.911147 \times 10^{-43}}\right) \times \frac{1}{0.391676 \times 2.5 \times 10^{-13} + \frac{2.01335 \times 10^{-25}}{5.391 \times 10^{-44}}}}$$

Result

3.545069560378408458542014468558801907747907279221760366633963 8858
…

3.54506956037….

From which:

(1/4((1/((((((1.80951×10^-8)/(299792458)^2 + (2.01335×10^-25)/(1.911147*10^-43))))1/(((((0.391676*2.5*10^-13)+(2.01335*10^-25)/(5.391*10^-44)))))))^2))

Input interpretation

$$\frac{1}{4}\left(\frac{1}{\left(\frac{1.80951\times10^{-8}}{299\,792\,458^2}+\frac{2.01335\times10^{-25}}{1.911147\times10^{-43}}\right)\times\frac{1}{0.391676\times2.5\times10^{-13}+\frac{2.01335\times10^{-25}}{5.391\times10^{-44}}}}\right)^2$$

Result

3.141879546980390553847706977157728727317474901786683621263641821 1
...

3.14187954….≈ π

1/6(1/4((1/((((((1.80951×10^-8)/(299792458)^2 + (2.01335×10^-25)/(1.911147*10^-43))))1/(((((0.391676*2.5*10^-13)+(2.01335*10^-25)/(5.391*10^-44)))))))^2))^2

Input interpretation

$$\frac{1}{6}\left(\frac{1}{4}\left(\frac{1}{\left(\frac{1.80951\times10^{-8}}{299\,792\,458^2}+\frac{2.01335\times10^{-25}}{1.911147\times10^{-43}}\right)\times\frac{1}{0.391676\times2.5\times10^{-13}+\frac{2.01335\times10^{-25}}{5.391\times10^{-44}}}}\right)^2\right)^2$$

Result

1.645234514622284028902101656523421307050771145683884185826835832 9
...

1.645234514….≈ ζ(2) = $\frac{\pi^2}{6}$ = 1.644934 ... (trace of the instanton shape)

Conclusions

We conclude this paper by highlighting how even in these two Maxwell equations, by carrying out some calculations, we obtain two results 1.643707 and 1.645234514 very close to the value of $\zeta(2)$ and $3.14187954\ldots \approx \pi$