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Why does c appear in equations of physics and have various exponents?

Abstract: The purpose of this article is to suggest answers to the follow two questions, namely, Why does *c* (the speed of light) show up in various physics equations? and Why does *c* have various dimensions (exponents) in these equations? The discussion opens with a treatment of gamma, an important factor used in Special and General Relativity. ~~This is followed by presentations about dimensions, rotation, the Expansive Ether, gravitation, scalar motion, and reference system limitations.~~ An Appendix gives the space/time dimensions for selected items (mostly electrical) used in non-local physics.

Introduction

The purpose of this article is to suggest answers to the follow two questions:

1. Why does *c* (the speed of light) show up in various physics equations?
2. Why does *c* have various dimensions (exponents) in these equations?

Here are three examples of well-known formulas rewritten in non-local form that help to illustrate the meaning of these two questions:

$$\frac{E}{\frac{1}{c^1}} = \frac{m}{\frac{1}{c^3}} \qquad \frac{E}{\frac{1}{c^1}} = \frac{p}{\frac{1}{c^2}} \qquad E = \frac{B}{\frac{1}{c^1}}$$

$$energy - mass \qquad energy - momentum \qquad electric - magnetic$$

The pattern suggested by these equations indicates a deeper meaning about space/time relationships than what is typically presented in the textbooks and professional journals. Institutional physics is mostly about "local physics" where cause and effect are based on spatial contact or spatial proximity. The influences are propagated at ordinary speeds that are less than the speed of light. It is very intuitive and easily understood.

The other kind of physics is called "non-local physics". It is based on "action at a distance" whereby cause and effect do not appear to have a spatial origin. The cause of the actions seems to be instantaneous, non-directional, and not propagated in space. Gravitation is an example (current theory notwithstanding). This kind of physics is non-intuitive and often has astonishing effects and implications. Physicists are not comfortable with it, and sometimes call it "voodoo physics". Except for Quantum Mechanics, it is a topic that has been mostly ignored for the past 100 years.

The presentation here is based mostly on non-local physics. Note that Special and General Relativity are specifically *local theories* by design and intent. Cause and effect are spatial, and speeds are limited to less than that of light. *Non-local phenomena are out of scope for these types of theories* Therefore this presentation could be a difficult topic for some readers due to their education in "received truths" and preconceptions. But they should give it a try with an open mind. Much of this could have been presented 100 years ago.

We will start with an easy preliminary, the meaning of gamma in Special Relativity. The reader will see that it has a lot of important implications, and only a few are covered here. But first a few things must be said about the nature of space and time in non-local physics.

Space, Time, and Non-local physics

In non-local *physics* space and time have identical characteristics. They do not appear that way to us because we are immersed in a gravitational reference system (more on this later) Time progresses but so does space (known as the Hubble expansion). Space has three independent linear dimensions but so does time. These two are always linked together in a ratio that we call motion. This is not the Minkowski space-time in Relativity theory. Consequently, the preferred terminology here is "space/time" or "time/space" instead of "space-time".

Picture two photons originating at a point in space and moving directly away from each other. Each photon moves one unit of space per one unit of time. Hence, the total spatial separation starts out as two units of space per one unit of clock time. But time is three dimensional like space. And because time acts like space *at a fundamental level*, the total time separation is actually also two units. The progression is then 2/2, 4/4, 6/6, etc. The numerator and denominator are always changing, but the *ratio* remains constant. This is the reason for the "constancy of the speed of light" (in a vacuum, and in an inertial (unaccelerated) reference system). Experiments show that the photons must be separating at the speed of c, NOT $2c$, as would normally be expected. Hence, the speed of light is regarded as a universal, absolute speed constant.

Because time and space are both three-dimensional, we have to deal with two types of location (one in space and one in time). A classical experiment can "down convert" a single ultraviolet photon into two red photons. The red photons then separate spatially in the context of the laboratory and move to different spatial locations. But because of experimental conditions, the photons remain in the same *time* location. They are both separate (in space) and yet are still together (in time). An effect imposed on one photon has an *instantaneous* complementary effect on the other photon, even if it is miles away. This is the well-known EPR Paradox. The effect has been confirmed in various experimental setups of different designs.

Could there also be an "Inverse EPR paradox"? Could two realities overlay each other seemingly at the same time and in the same space? The effect would be like seeing a double exposure on a photograph. What has been physically demonstrated is two objects merging into the same location, such as a piece of wood merging into an aluminum bar, without the expected burning or displacement (upheaval) of metal. This is NOT an effect currently acknowledged by the scientific community. But the presentation here does not rule it out either.

The Relativistic Correction Factor, Gamma (γ)

If you study Special or General Relativity you will soon encounter the "relativistic correction factor", gamma, which is usually given as:

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

The spatial velocity term, v, is the conventional speed of the object in motion and c is the speed of light. Gamma itself is just a dimensionless (pure) number. As per the formula, γ is approximately 1 at ordinary

terrestrial speeds. At speeds 99.9% of light, γ becomes about 22. It is a correction factor, not something that stands alone, and applies to speeds in space. It is used to compute relativistic momentum, relativistic energy, length contraction and time dilation at high speeds.

With some elementary math, we can rearrange it into a different form:

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$\mathbf{1 - v^2/c^2 = 1/\gamma^2}$$

$$\mathbf{1 = 1/\gamma^2 + v^2/c^2}$$

$$\mathbf{c^2 = c^2/\gamma^2 + v^2}$$

The last form of the equation suggests that:

- In a gravitational reference system *everything* moves at the speed of light.
- The complete speed relative to such a system actually has two orthogonal components: a temporal speed and a spatial speed.
- When the spatial speed is zero (v=0), the speed of the system is entirely in time. Time flows at the speed of light, but space "stays put" or "is stationary" The total effect can be called *history*. This is what we perceive as a normal environment.
- If the system is moving at the (spatial) speed of light (v=c), then space flows, and time "stays put" or "stops". This effect is called “time dilation”.
- The two speeds cannot be directly summed together because temporal speeds (t/s) and spatial speeds (s/t) are measured in different units. The temporal speed must be changed into an equivalent spatial speed by the gamma correction factor (a pure number) which changes its magnitude into an equivalent spatial speed.

> Time and space are always linked together somehow. A temporal magnitude has an equivalent spatial magnitude. Temporal motion has a spatial motion equivalent.
>
> Consider an electrical capacitor. Its capacitance is dependent on the permittivity of the dielectric (a time structure) separating the plates. But what if the dielectric is a vacuum? It turns out that the space separating the plates has a temporal equivalent even though it is empty. In fact, free space still has the characteristics of permittivity, permeability, and impedance. Example: the intrinsic *impedance* Z_0 of free space is approximately 377 ohms.

In this interpretation, we can immediately see the reason for time dilation at speeds comparable to that of light. At *c*, the phenomena remains in the same time unit and does not experience the flow of time. At speed *c*, clocks would have an indefinitely long tick. Unstable particles would have indefinitely long life-

times. At speeds slightly less than light, time flows a little bit, but not nearly as fast as we normally experience it.

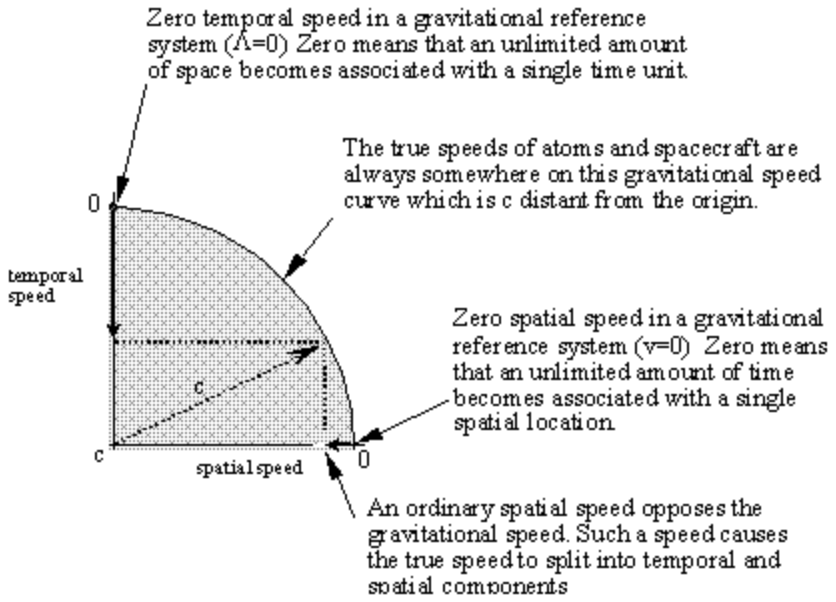
Temporal motion is non-directional. And it is motion in time, not space. Objects with this kind of motion have no (spatial) trajectory and appear stationary. They are still moving and have momentum which resists a change in spatial position or direction. In various contexts we call this effect “inertia” or “motionless motion”. And because it is non-directional it can also be called “thermal motion”, or “diffusion”. Apparently, true “non local motion” is also possible: an object can move from one location to another location without traversing the intervening space.

Energy is a better measure of the "amount of motion" at relativistic speeds than spatial velocity. The natural, fundamental pattern for speed is c, the speed of light, and its inverse is 1/c, which has the dimensions of energy. This explains the behavior of particles in a particle accelerator. An electron with a speed of 0.995 that of light, has an energy of about 15 MeV. At a speed of 0.99999995 that of light, it has an energy of 5 GeV. Note that the speed has increased by a factor of only 1.0005 but the energy has increased by a factor of 300. How can there be such a huge increase in energy with only a tiny (5 parts in ten thousand) speed increase? It is because the measure of the "amount of motion", namely speed as a change of spatial position, is misaligned with the problem. One could say, “The faster it moves, the more it slows down”. Speeds less than that of light are spatial. Speeds greater than light are temporal. There is no “speed barrier” at *c*. The spectrum is continuous. Mass is constant and does not increase with increasing speed. It is only the *measure of motion* that inverts. Above light speed we have to use energy (t/s) instead of spatial speed (s/t). Energy is scalar (has only a magnitude). Spatial speeds are vectorial (have magnitude and direction).

An exception to this restraint is the Doppler shift of light. The Doppler shift is based on *frequency*, and does not necessarily indicate a rate of change of spatial location. Temporal motion can cause a frequency shift too, and it can do so without a change in spatial position. We see this effect with the quasars, which often have extreme redshifts and implied speeds several times that of light. Quasars are ejected from galaxies by a very energetic explosive process. Initially the speeds are spatial, but as the galactic gravitational retardation effect decreases with increasing distance, the explosion speed component becomes more effective, and the quasars speed up. Eventually, they reach light speed and the motion becomes temporal. The quasars then appear to have stopped their spatial motion and remain in the same position “near” the galaxy. An “active” galaxy may thus have several quasars associated with it (e.g., NGC 3516, 5985). The inversion at the speed of light also causes these galactic fragments to shrink from the standpoint of the reference system (similar to “length contraction” in Special Relativity), and to appear starlike, instead of appearing as an ejected galactic fragment several hundred light years in extent. The extreme Doppler shift and tiny size are solid indications of temporal motion, or “speeds greater than that of light”

I prefer to illustrate the relationship of the two speeds with the following diagram:

Speeds in a gravitationally bound reference system



A non-gravitating object like a photon always moves at the speed of light. Its position on the diagram would be at the origin. Note that the origin is not zero. The origin represents the "no motion" datum for the physical universe (photons are actually stationary, but the "fabric" of space and time expands at the speed c) The speed is divided equally between space and time in a 1/1 ratio. The expansion of space (numerator) is exactly cancelled out by the expansion of time (denominator) and vice versa. The "flow" of either is apparent only when space and time are considered separately as abstractions (not as an inseparable ratio).

A gravitating object like a star also moves at the speed of light, but its speed is not split equally between space and time. In this case, an unlimited amount of time becomes associated with a single spatial position (time flows, space is stationary. Loosely, $s/t = 1/\infty$).

A gravitating object like a spacecraft also moves at the speed of the gravitational system. However, it may have an additional speed imposed on its gravitating atoms. The spatial and temporal components of this speed must still sum to the speed of light. At speeds near that of light, the true speed is almost entirely spatial (space flows, time is stationary. Loosely, $s/t = \infty/1$)

Note that there are no zero or infinite speeds in this system. There aren't even any non-c speeds! These supposed "other speeds" are only abstractions convenient to humans.

Please note the following:

- The diagram depicts *speeds*, that is, *motion*—a *ratio* of space and time

- Speed *c* is at the origin. In conventional mathematics this is where the x and y axes cross and is usually assigned the value of zero. But that is not the case here. This entire diagram is about motion, a ratio of space and time. In this ratio the numerator and denominator both progress toward increasing time separation and increasing space separation. But the ratio of the two remains constant. This is a new datum for no motion, no activity.

"Nothing happens until something moves." —Albert Einstein

- There are actually *two* zeros. They are at the outer ends of the perpendicular lines. One depicts zero motion in time and the other is zero motion in space.

- Each single perpendicular line offers two ways to measure motion. There is the normal way and the natural (fundamental) way. The latter uses displacement away from the origin where speed c is taken as the fundamental zero. (This gives a hint, incidentally, as to why *c* shows up frequently in fundamental physics equations.) The other measure is a displacement away from the zero at the outer end of the line. This is the familiar "relative motion" we experience in everyday life.

- Motion of either type is quantized. Neither can go below one unit. Hence, there is no true mathematical zero. The meaning of "zero" here is that (for example) an unlimited amount of time can become associated with one unit of space. This is the situation described by Quantum Mechanics. In the microphysical world, space is fixed at one unit and all the variation is in time. There are no spatial trajectories, and analysis must use "non-path" schemes like total energy to characterize a system. This results in weird equations where all the "things" are mathematical "operators" and the scheme (the "mechanics") is very non-intuitive.

- The curve that connects the two axes represents all (linear) speeds. Again, *everything* moves at the speed of light. All motion is a combination of a temporal speed and a spatial speed.

- Some deep thought about this curve gives some insight about the so-called Twin Paradox in Special Relativity. In this "thought paradox" one twin stays on Earth and the other goes away in a rocket ship at some significant fraction of the speed of light. At near light speed, time slows down. Hence, upon his return, he has aged *less* than his twin on Earth. But this is not the official paradox; this is just a simple prediction of Special Relativity. The paradox is that *either* twin can be viewed as being younger than the other, because the motion can only be "purely relative". The fact that the *cause* of one type of motion can be distinguished from the other is irrelevant to the paradox. (That physicists so readily accept this paradox as science (which itself has not been demonstrated) says some really awful things about our science institutions.)

  The deep meaning in this diagram implies that there is no paradox. The twin moving at high speed, ages relative to a "flow-of-space clock", with *time* not progressing as fast as it usually does, and the twin on Earth, ages relative to an ordinary "flow-of-time clock" with *space* not progressing. Both age at the same rate (but on different types of clocks), and have the same final age back on Earth. There is no paradox if the ages are referred to the progression of an "orthogonal sum" clock that incorporates *both* time and space progression effects. The effects of *both* local and non-local behaviors need to be taken into account.)

And so what does all this mean for *c* in the gamma equation? The *c* appears in the gamma equation because everything moves (linearly) at the speed of light. The total speed is a combination of

temporal speed and spatial speed. The speeds are combined by a Pythagorean-like calculation of "Euclidian distance", which uses c^2 instead of just c.

Selected references:

"Beyond Einstein: non-local physics, 8 th ed"
https://www.academia.edu/165332593/Beyond_Einstein_non_local_physics_8_th_ed

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https://www.universetoday.com/articles/a-dense-group-of-quasars-form-the-cosmic-himalayas

Appendix A: Presumed space/time dimensions for selected electrical quantities

Electric field intensity	[=]	t/s^3	volts/cm	E
Frequency	[=]	$1/t$	Hertz	f
Inductance	[=]	t^3/s^3	Henry	L
Mass	[=]	t^3/s^3	kilograms	m
Resistance	[=]	t^2/s^3	Ohms	R
Permittivity	[=]	s^2/t	farads/meter	e
Permeability	[=]	t^3/s^4	henry/meter	m
Power	[=]	$1/s^1$	watts	W
Poynting vector	[=]	$1/s^3$	power per area	S
Reactance	[=]	t^2/s^3	Ohms	X
Impedance	[=]	t^2/s^3	Ohms	Z
Current	[=]	s/t	amperes	i, I, A
Voltage	[=]	t/s^2	volts	V
Magnetic field intensity	[=]	t^2/s^4	oersteds	H
Magnetic flux	[=]	t^2/s^2	Maxwell	ϕ
Q	[=]	1/1	ratio of reactance to resistance. (dimensionless)	
Time	[=]	t	seconds	τ, t, t_d

Inductance is magnetic flux divided by current:	**Energy stored in an inductor**	**Voltage across an inductor with changing current**
$L = \frac{\phi}{I}$ $= \frac{t^2}{s^2} \cdot \frac{t^1}{s^1}$ $= \frac{t^3}{s^3}$	$E = ½Li^2$ t/s [=?] (t^3/s^3) (s^2/t^2) t/s [=] t/s	$V = Ldi/dt$ t/s^2 [=?] $(t^3/s^3)(s/t)(1/t)$ t/s^2 [=] t/s^2

Time constant for inductance + resistance $t = L/R$ $t\ [=?]\ (t^3/s^3)(s^3/t^2)$ $t\ [=]\ t$	**Inductive reactance (X_l)** $X_l = 2\pi fL$ $t^2/s^3\ [=?]\ (1/t)\ (t^3/s^3)$ $t^2/s^3\ [=]\ t^2/s^3$	

Time constant for an RC circuit $t = RC$ $t\left[=?\right]\frac{t^2}{s^3}\frac{s^3}{t^1}$ $t\left[=\right]t$	**Time delay of an artificial transmission line** $t = \sqrt{L \cdot C}$ $t\left[=?\right]\sqrt{\frac{t^3}{s^3}\cdot\frac{s^3}{t}}$ $t\left[=\right]t$	**Capacitive reactance** $Xc = \frac{1}{2\pi f C}$ $\frac{t^2}{s^3}\left[=?\right]\frac{1}{\frac{1}{t}\frac{s3}{t}}$ $\frac{t^2}{s^3}\left[=\right]\frac{t^2}{s^3}$
Q of series RLC $Qseries = \frac{1}{R}\sqrt{\frac{L}{C}}$ $\frac{1}{1}\left[=?\right]\frac{1}{\frac{t^2}{s^3}}\sqrt{\frac{t^3}{s^3}\frac{t^1}{s^3}}$ $\frac{1}{1}\left[=?\right]\frac{s^3}{t^2}\sqrt{\frac{t^4}{s^6}}$ $\frac{1}{1}\left[=\right]\frac{1}{1}$	**Q of parallel RLC** $Qparallel = R\sqrt{\frac{C}{L}}$ $\frac{1}{1}\left[=?\right]\frac{t^2}{s^3}\sqrt{\frac{s^3}{t^1}\frac{s^3}{t^3}}$ $\left[=?\right]=\ \frac{t^2}{s^3}\frac{s^3}{t^2}$ $\frac{1}{1}\left[=\right]\frac{1}{1}$	**Frequency of resonance for LC circuit** $f_r = \frac{1}{2\pi\sqrt{LC}}$ $\frac{1}{t}\left[=?\right]\frac{1}{\sqrt{\frac{t^3}{s^3}\frac{s^3}{t^1}}} = \frac{1}{t^1}$ $\frac{1}{t}\left[=\right]\frac{1}{t}$

Impedance of a series LC circuit $Z = \sqrt{\frac{L}{C}}$ $\frac{t^2}{s^3}\left[=?\right]\sqrt{\frac{\frac{t^3}{s^3}}{\frac{s^3}{t^1}}} = \sqrt{\frac{t^3}{s^3}\cdot\frac{t^1}{s^3}}$ $\frac{t^2}{s^3}\left[=\right]\frac{t^2}{s^3}$	**Current through a capacitor** $i = C\frac{dv}{dt}$ $\frac{s}{t}\left[=?\right]\frac{s^3}{t}\ \frac{t}{s^2}\ \frac{1}{t}$ $\frac{s}{t}\left[=\right]\frac{s}{t}$	**Energy stored in a capacitor** $W = \frac{1}{2}CV^2$ $\frac{t}{s}\left[=?\right]\frac{s^3}{t}\frac{t^2}{s^4}$ $\frac{t}{s}\left[=\right]\frac{t}{s}$
Permittivity [=] s^2/t ; **ε** Permeability [=] t^3/s^4 ; **μ** $1/c^2 = \mu\varepsilon$ t^2/s^2 [=?] $(t^3/s^4)(s^2/t)$ t^2/s^2 [=] t^2/s^2	**Impedance of free space** $Z = \sqrt{\frac{\mu}{\varepsilon}}$ $\frac{t^2}{s^3} = \sqrt{\frac{\frac{t^3}{s^4}}{\frac{s^2}{t^1}}}$	**Faraday's law of induction** $\nabla xE = -\partial B/\partial t$ $(1/s)(t/s^3)$ [=?] $(t^2/s^4)(1/t)$ (t/s^4) [=] (t/s^4)
Poynting vector $S = \varepsilon_0 c^2(ExB)$ $= \frac{s^2}{t}\frac{s^2}{t^2}\frac{t}{s^3}\frac{t^2}{s^4}$ $= \frac{1}{s^3}$	**Poynting vector** $S = (1/\mu_0)(ExB)$ $= \frac{s^4}{t^3}\frac{t}{s^3}\frac{t^2}{s^4}$ $= \frac{1}{s^3}$	

Appendix B: The search for the "quackpot"