Some Implications of an Imaginary Speed of Dark

Philip Machanick
Department of Computer Science
Rhodes University, Grahamstown 6140
South Africa
p.machanick@ru.ac.za

June 9, 2014

Abstract

The Lorenz factor $\gamma \to \infty$ as $v \to c$. However if c is replaced by an imaginary number id, v can be arbitrarily large and $\lim_{v \to \infty} \gamma = 0$. If we see the speed of light, c, as a physical constant used in transforming reference frames, there is no reason to see c as an actual speed. If we instead see it as a constant with the dimensions of velocity, there is no reason not to have an imaginary analog. Nonetheless, for terminological symmetry, I call the imaginary analog of the speed of light, id, the *speed of dark* and explore some implications of such an imaginary physical constant. These implications include a model of the universe in which dark energy and matter are globally observable but not locally, and the possibility of faster than light communication, energy transmission and matter transmission.

1 Introduction

The Lorenz factor (Forshaw and Smith, 2009)

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

is an essential part of special relativity, and defines time dilation and length contraction. It is also the theoretical basis for the view that faster-than-light communication is impossible, as any value for relative velocity v that exceeds the speed of light c results in a negative square root, and $\lim_{v \to c} \gamma = \infty$.

Here I examine the possibility that c has an imaginary counterpart, id, and the implications of that possibility. Since c is the familiar variable for the real component, and is called the speed of light, I call the imaginary value id the *speed of dark*, for the reasons soon to be made clear.

The imaginary Lorenz factor $\gamma^{(i)}$ is

$$\gamma^{(i)} = \frac{1}{\sqrt{1+\frac{v^2}{d^2}}} \tag{2}$$

and for $v = d$, $\gamma^{(i)} = \sqrt{\frac{1}{2}}$. More interestingly, $\lim_{v\to\infty} \gamma^{(i)} = 0$. As with the real version, for $\lim_{v\to 0} \gamma^{(i)} = 1$, i.e., for sufficiently small v, Newtonian mechanics applies.

In this paper I outline some implications of imaginary Lorentz transformation. These implications include the possibility of an infinitely-fast expansion of the initial universe in "dark" energy and matter mode, a vestige of that expansion still being observable in a form that precludes local observation but has a global effect on the universe and a possibility of faster-than-light matter, communication and energy transfer, should it be possible to recreate locally "dark" conditions.

2 Dark and Light Universes

I hypothesise a dark universe, in which c=0, and a light universe in which d=0. The value id is the *speed of dark*, and represents a c-like term for relativistic coordinate system transformation in the dark universe. Since id is an imaginary number, $d^2 < 0$, though the magnitude of d remains to be determined. We can apply the usual Lorentz transformations for length and time, to a new coordinate system with relative velocity v:

$$\begin{aligned} t' &= \gamma^{(i)}(t - \frac{vx}{id^2}) \\ &= \gamma^{(i)}(t + \frac{vx}{d^2}) \\ x' &= \gamma^{(i)}(x - vt) \end{aligned} \tag{3}$$

First, in the time dimension, since $\lim_{v\to\infty} \gamma^{(i)} = 0$:

$$\begin{aligned} \lim_{v\to\infty} t' &= \lim_{v\to\infty} \gamma^{(i)} \frac{vx}{d^2} \\ &= \lim_{v\to\infty} \frac{vx}{(\sqrt{1+\frac{v^2}{d^2}})d^2} \end{aligned}$$

$$
\begin{aligned}
&= \lim_{v\to\infty} \frac{x}{\frac{1}{v}(\sqrt{d^4+d^2v^2})} \\
&= \lim_{v\to\infty} \frac{x}{(\sqrt{\frac{d^4}{v}+d^2})} \\
&= \lim_{v\to\infty} \frac{x}{\sqrt{d^2}} \\
&= \pm\frac{x}{d} \qquad (4)
\end{aligned}
$$

Now, the length dimension:

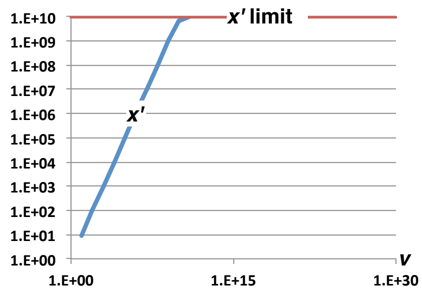
$$
\begin{aligned}
\lim_{v\to\infty} x' &= \lim_{v\to\infty} -\gamma^{(i)}vt \\
&= \lim_{v\to\infty} -\frac{vt}{\sqrt{1+v^2/d^2}} \\
&= \lim_{v\to\infty} -\frac{t}{\frac{1}{v}\sqrt{1+\frac{v^2}{d^2}}} \\
&= \lim_{v\to\infty} -\frac{t}{\sqrt{\frac{1}{v^2}+\frac{1}{d^2}}} \\
&= \lim_{v\to\infty} -\frac{t}{\sqrt{\frac{1}{d^2}}} \\
&= \mp td \qquad (5)
\end{aligned}
$$

So in the dark universe, as relative velocity $v \to \infty$, relative time t' becomes proportional to the distance of the observer from the observed event, and relative length proportional to elapsed time t since the event.

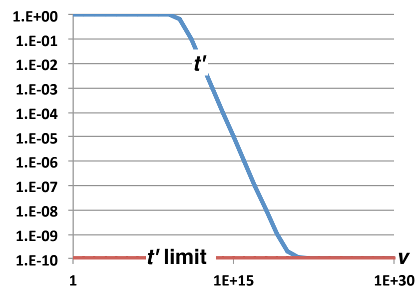
Figure 1 illustrates the effect of these transformations for an arbitrarily-chosen value of d. The shape of the curves will be the same but scaled differently for the actual value of d. Since a square root yields positive or negative values, I take the positive value as that with a physical interpretation, absent any evidence that I should do the contrary.

3 Dark and Light Matter

This brings me to the question of whether the choice of “dark” as a label is only a word game. One of the mysteries of cosmology is accounting for dark matter. If the early universe expanded infinitely fast in dark mode as outlined here, relative time during that event would be purely a function of distance from the observer.



(a) x transformation



(b) t transformation

Figure 1: Transformations for $\gamma^{(i)}$ with arbitrary $d = 1 \times 10^{10}$

That infinitely fast expansion phase is followed by a slowdown to relativistic speed of expansion, transforming from a dark (coordinate transformations use id) to light (coordinate transformations use c) universe.

So as the universe expands in its present light mode, any observer will see the time of the big bang nucleosynthesis event as stationary relative to the point of observation (equation 4). On the other hand the size of the initial infinitely expanding universe will appear to be proportionate to elapsed time (equation 5). If we know how big the universe was at the time of the transition from light to dark, we can calculate its apparent size at the present. On the other hand, if we can determine its apparent present time, we can calculate its size at the time of the transition.

The search for dark matter may be failing to produce results because we are looking in the wrong place.

In order to confirm these ideas, we need testable hypotheses. For a start, we know about dark matter because there is a measurable effect that cannot be accounted for by observable matter. Secondly, the time and length transformations as $v \to \infty$ yield constants. If we know the distance of the observer from other matter at the initial infinite expansion phase, we can calculate $\frac{x}{d}$. If we know the elapsed time since the infinite expansion event, we can calculate td. Either of these calculations allows us to derive d.

An order of magnitude estimate of time since bing bang nucleosynthesis is 10Gyr (Copi et al., 1995; Planck Collaboration, 2013a). Conventional cosmology has the universe expanding uniformly in all directions (Lemaître, 1931) rather than from a point. Assuming this model holds, we need an interpretation of "distance of the observer" from the initial expansion point, which does not exist. The answer to this dilemma is to choose an arbitrary point in space and measure that point relative

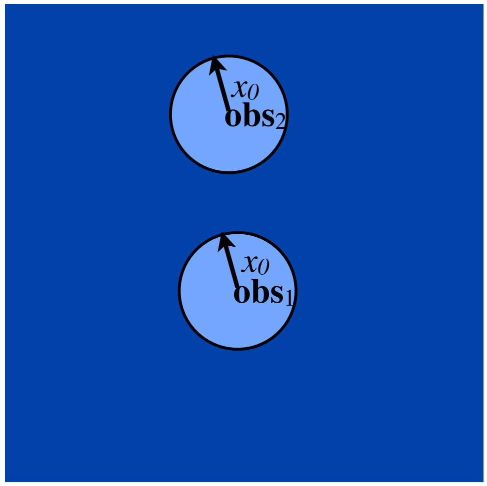


Figure 2: Light bubbles in the observable the dark universe

to the observer. If there is no evidence of dark matter at that point, then we are at a distance $< td$ where $t \approx 10^9 Yr$ from that point. If we can establish a boundary at distance x_0 from the observer at which dark matter becomes observable, we have an estimate for $d \approx \frac{x_0}{10^9 Yr}$. How is dark matter observable in this sense? We need a measure of its *local* gravitational effect, because it will not have a gravitational effect on anything within its x_0 radius.

Figure 2 illustrates how observers in different positions will not observe dark matter locally, yet the observer at a different position, distance $> x_0$, will observe dark matter at the other observer's locality. Each observer has a *light bubble* of radius x_0 surrounding them in which locally there is no observable dark matter, but outside this radius, dark matter appears to be pervasive. Effects of the presence of dark matter outside the radius x_0, while measurable at the observer, will not result in local interactions since the observed dark matter at any point in the universe will always be at a distance x_0. This, observer at location obs_1 will be able to measure effects of dark matter in the vicinity of observer obs_2 at a distance $> x_0$ from obs_1, but will not be able to detect any effects of local interaction at obs_2 since obs_2 does not see any dark matter with its light bubble.

If the theory holds, once we have an estimate for d, we can check if at distance $> x_0$, the time transformation starts to hold, i.e., we expect that $\frac{x_0}{d} \approx 10^9 Yr$.

Experimental verification therefore requires ability to measure gravitational effects of sufficiently distant space to be able to determine where dark matter starts to become observable. Once we have an estimate for x_0, the rest follows.

4 Transformation from Dark to Light

If the universe grew at infinite speed, then transformed instantaneously to the present light mode, the $\gamma^{(i)}$ transformation would have the effect that we would continue to see the mass of the universe at a distance td from any observer. In addition, any expansion of the universe since that primal event would not be observable in the effect of dark matter. That effect would be as if the additional "dark" matter was much larger than "light" matter. The best available estimate for the breakdown of total mass-energy of the universe at 4.9% "light" matter, 26.8% "dark" matter and 68.3% "dark" energy (Planck Collaboration, 2013b). Using as a first approximation a simple Newtonian gravitational calculation with an inverse square gravitational attraction and the assumption that the total mass of the universe in dark mode is the same as in light mode, the apparent $\approx 5.5\times$ quantity of dark matter versus light can be explained by the dark universe being smaller than the current light universe. If an inverse square relationship applies, this implies that in the dark universe as currently observed masses are $\frac{1}{\sqrt{5.5}} \approx \frac{1}{2.3}$ closer together than in the light universe.

If dark matter as we measure it now is in effect a vestige of a dark universe, then dark energy could represent the energy release at the instant before the dark universe translated to its present light mode. If that is the case, dark energy, as with dark matter, will appear to be amplified in its local effect by the $\gamma^{(i)}$ transformation. Again, assuming an inverse square law, if distances apart in the dark universe are $\frac{1}{2.3}$ of distances in the current universe, the apparent amount of dark energy should be reduced by a factor of ≈ 5.5.

5 Implications

The dark universe version of the Lorenz transformations yields testable results that solve one of the major dilemmas of dark matter observations: the fact that dark matter appears to be pervasive, yet not locally observable.

Further, the fact that the observable amount of dark energy is not orders of magnitude more than mass-energy of the light universe hints at the possibility that the reverse transformation on a small scale may be possible with modest expenditure of energy. Should it be possible to transform light matter or energy to dark and transform back again, that opens the possibility for faster than light energy transmission, communication and travel.

References

Copi, C., Schramm, D., and Turner, M. (1995). Big-bang nucleosynthesis and the baryon density of the universe. *Science*, 267(5195):192–199.

Forshaw, J. and Smith, G. (2009). *Dynamics and relativity*. Wiley, Chichester, UK.

Lemaître, G. (1931). Expansion of the universe, a homogeneous universe of constant mass and increasing radius accounting for the radial velocity of extra-galactic nebulae. *Monthly Notices of the Royal Astronomical Society*, 91:483–490.

Planck Collaboration (2013a). Planck 2013 results. I. Overview of products and scientific results. *arXiv preprint arXiv:1303.5062*.

Planck Collaboration (2013b). Planck 2013 results. XVI. Cosmological parameters. *arXiv preprint arXiv:1303.5062*.