Information is fundamental

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Abstract

This paper will argue that physical processes are driven by information. For us, information means a fundamental “reveal”. It means sharing of information through physical space, and sharing of information fuels change of motion. And ultimately, an entity that doesn't reveal anything about itself in any way does not really exist.
The argument in this paper, specifically, is centered around the hypothesis that physical entities can intrinsically carry and share information in space around it, and have the ability to use this shared information. The end result of carrying, sharing and using information is change of motion.

Introduction

The basic premise is reminiscent of the accepted generic model of a particle. There is a particle and a field around the particle. What we propose is to replace any specific “field” with the “field of information”. In many ways we already think of a physical field as a source of information, so the leap isn't that big. The difference is what we think this field is.

Hypothesis

The information field

We think of an elementary particle as surrounded by a field made of information carriers we call “avatars”.
Avatars contain some information about the particle.
Just like most fields, the density of avatars declines with the square of distance.
Avatars are not separate particles, they are tied to a particle in a most fundamental sense. When particle changes the state of motion, so do avatars, without any propagation delay – this is the meaning of them being intrinsically tied to a particle itself.
One way to think of avatars is that they flood the physical space with information. They effectively create a fundamental network of information.

The particle

We think of a particle as an information processor. Each particle swims in a soup of avatars, or more formally, a particle has access to avatars from all particles – at least to those avatars that exists in a point in space where the particle is.
Clearly, avatars from far-away particles are few and between, and those from close-by particles are aplenty. We say that “information influence” of close-by particles is greater than those far away.
Put simply, a particle collects avatars it encounters, uses the information they carry, and then acts on it. By “act” on it, we mean change the state of motion.

The world-view

If you have read about how we see particles and their interactions, the world-view is still very similar to what we know. Particles interact with one another. What's different is how they do it.
We explained that a particle has avatars that surround it to infinity, and that avatars move with particle as-one, without any delay. In essence, it's like each particle occupies all of the space.
And since avatars from all particles effectively are everywhere, particles use the information that avatars carry, and process it. The result of this processing is simply a decision where to move, and at which speed.
This is the world-view of informational Universe. We will now give it mathematics, to see if it leads somewhere familiar, and ultimately, useful – in a way of prediction that can differentiate this hypothesis as valid.

The final layer of reality

You'll notice that while we speak of information, particles and avatars, we don't go into much details as to what the “physical structures” may be that support this world-view and this hypothesis. This is because we don't care what the physical structure is, only that it exists. *Why?*
First of all, “caring” is a wrong word, although once we explain why, it may just be the right one.
If elementary particles carry and process information like we described, then we'll never be able to observe the actual supporting structures for this mechanism. If we could, then those particles wouldn't be elementary, because we would be (somehow) extracting information from physical entities that use this information for their very functioning. There is no way to do that, lest those entities are not elementary.
For that reason, we shouldn't really care what the physical structures may be, so we don't care.
But what we do care about is what these physical structures must support, in terms of function. And that, we can and will deduce. The reason for this optimism is because we can safely assume that Nature at its core isn't going to complicate things beyond what's necessary.
And if information processing is indeed at its core, then this processing is something we can logically expect to work in a certain way. Once we strip away physical assumptions about information processing, there are some inevitable and inescapable traits that such information processing must comply with, regardless of what level of reality you look at, including the very fundamental one. We'll talk more about this.
This hypothesis is all about this inevitable and inescapable traits, and about turning these traits into mathematics.

The first mathematics

We said that particles collect information from information carriers (i.e. avatars), and use it to change the motion. But what exactly are the minimum requirements in a particle, for this to even be possible?
We describe motion of a particle via two things: a point in space where motion begins and a point in space where it ends, all in some fixed period of time. Thus, change in motion *requires information from two points in space*, if this motion is to happen at all.
This means a particle must need two pieces of information for this, from two different points in space, and consequently, two different moments in time. In addition, *the two different points in space must constantly change* so that they cover any direction around the particle, or otherwise there will be directions where a particle cannot go. This is because there would be points in space that are unknown to the particle, so why would particle decide to go there?
So to satisfy the two-point requirement in general, a particle must have two pieces of information. The simplest way to achieve that is to collect one piece just a moment ago, and the second piece just now. By comparing the two pieces of information, it is now possible to determine whether a particle should change the motion.
To satisfy a constant-change-of-two-points requirement, a particle, while moving in any direction, must randomly zigzag so to still remain practically in the same position. This random zigzag motion makes a particle remain in the spot on average, but it also gives it an opportunity to compare the information of two points in any direction around it. It's as if a particle moves randomly in some confined space around its location, and examines each point where it goes.

> *For example*, if a particle is moving along x-axis, it could zigzag 1 nanometer 30 degrees toward y-axis and -40 degrees toward z-axis, and then back. In doing so, a particle can now compare information at that location with the information at its previous position, and determine whether, and by how much, to change direction and speed. With this zigzag motion, a particle can change motion in any way possible, based on the information from avatars around it.

The question is, what is this “confined space” in which a particle must zigzag? There is no reason for it to be of any particular size, so we can say that a particle will spend a lot more time closer to its location, and a lot less time further away from it. The reason is clear: far away particles will have less information influence, and “probing” their information isn't a priority. But there is no limit as to how far away a particle might zigzag from its location, it's just that probability for it being really far away is really small.
Consider for a second that the above description gives rise to quantum behavior, which on the face of it seems impossible to explain, without knowing that it actually exists via an experiment.
Let's put this to math. Two information pieces a particle must have are collected “before” and “now”. We'll call

them “previous” and “current” information, and denote as i_p^n for “*p*revious information” of particle n and i_c^n for “*c*urrent information” of the same particle.

When a particle processes information, the simplest and most efficient way of doing so is to pair all previous information with all current information. Anything less would leave some information unaccounted for, and anything more would pair information that's already been paired. So the number of pairings is:

$$P^n = i_p^n \times i_c^n \quad (1)$$

A particle has some finite information storage for both previous and current information, so we write:

$$i_p^n + i_c^n = constant = I^n \quad (2)$$

Essentially, I^n is the information capacity of a particle n and it doesn't change.

If we assume all particles in the Universe are stationary, then on average the storage for previous and current information should be the same, because they only represent two different points in time, so, in a stationary Universe:

$$i_p^n = i_c^n = I^n / 2 = i^n \quad (3)$$

In the same setup, the throughput of information in a particle will be clearly i_c^n - this is the amount of information flowing through a particle right now. So, the throughput is (subscript 0 in throughput T^n means “at rest”):

$$T_0^n = i_c^n = \sqrt{i_p^n \times i_c^n} = \sqrt{i^n \times i^n} = i^n \quad (4)$$

Now we will assume that particles move relative to each other. The number of avatars that flow through a particle clearly increases proportional to the relative speeds of particles. Assume we have N particles total, and the distance between some particle p and our particle n is d_{pn} , while the their relative speed is v^{pn} , and we have for this “extra” information:

$$\Delta i^n = k \times \sum_{p=0}^{N} \left(i^n \times \frac{i^p / d_{pn}^2}{\sum_{a=0}^{N} i^a / d_{an}^2} \times v_{pn} \right) \quad (5)$$

The “extra” information Δi^n in particle n is proportional to the information in other particles divided by the square of distance between them (because avatars density declines with the square of distance), and their relative speed because the higher the relative speed the more avatars from p will be “seen” in n . We add a constant k for completeness, even if at the moment we don't really have any system of measurements for this.

> *How did we arrive at the summation element above for the extra information that particle sees when there's motion?*
>
> The expression $i^n \times \frac{i^p / d_{pn}^2}{\sum_{a=0}^{N} i^a / d_{an}^2}$ simply gives an average number of avatars from particle p that will be seen in particle n . To understand this, let's start from the beginning. Firstly, $\sum_{a=0}^{N} i^a / d_{an}^2$ is the total number of avatars from all particles at the location of n . Then, $\frac{i^p / d_{pn}^2}{\sum_{a=0}^{N} i^a / d_{an}^2}$ is the share of particle p 's avatars in this total number. For example, there could be 1,000,000 avatars present at the location of particle n , and these avatars come from all particles. If out of these 1,000,000 avatars, there is 1000 from particle p , then the share of particle p 's avatars at the location of n is $\frac{1{,}000}{1{,}000{,}000} = 0.001$, meaning one tenth of a percent of all avatars come from p . Since all avatars have equal chance to be actually collected and used by n , then the actual number of avatars used by

n that come from p is $i^n \times \frac{i^p / d_{pn}^2}{\sum_{a=0}^{N} i^a / d_{an}^2}$. Next, the higher the relative speed between n and p, the more of these avatars will be actually collected in a fixed unit of time, hence it will be $\left(i^n \times \frac{i^p / d_{pn}^2}{\sum_{a=0}^{N} i^a / d_{an}^2} \times v_{pn}\right)$, with constant k moderating the impact of relative speed v_{pn}. Finally, we add all these extra avatars from all particles, and we arrive at the most probable number of extra avatars from all particles.

What can a particle do with this "extra" information that comes from particles moving around relative to each other? It should take it into consideration, but the storage is limited. This is the extra information collected into i_c^n, i.e. into the current information. But, then some of the extra storage that goes into storing this extra information must be taken from the previous information i_c^p in order for total storage to remain constant:

$$\tilde{i}_c^n = i_c^n + \Delta i^n \quad (6)$$

$$\tilde{i}_p^n = i_p^n - \Delta i^n \quad (7)$$

The "tilde" denotes new storage allocated to current and previous information, in order for total to remain constant:

$$\tilde{i}_c^n + \tilde{i}_p^n = i_c^n + i_p^n = const \quad (8)$$

The throughput of information is now:

$$\tilde{T}^n = \sqrt{\tilde{i}_p^n \times \tilde{i}_c^n} = \sqrt{(i^n + \Delta i^n) \times (i^n - \Delta i^n)} = i^n \sqrt{1 - \left(\Delta i^n / i^n\right)^2} \quad (9)$$

From above equation (5):

$$\Delta i^n / i^n = k \times \sum_{p=0}^{N} \left(\frac{i^p / d_{pn}^2}{\sum_{a=0}^{N} i^a / d_{an}^2} \times v_{pn} \right) \quad (10)$$

A note about our summing expression above, related to our previous talk about particles "influencing" one another via information:

As we explained, $\frac{i^p / d_{pn}^2}{\sum_{a=0}^{N} i^a / d_{an}^2}$ is the average percentage of avatars from particle p that particle n can use. This is a cool number because it tells us how much particle p's information influences n. This is the mathematical expression of *information influence* we talked about before, and that's the name we give it. We denote it as f_{pn}:

$$f_{pn} = \frac{i^p / d_{pn}^2}{\sum_{a=0}^{N} i^a / d_{an}^2} \quad (11)$$

It is obvious that sum of all information influence on a particle is exactly 1. This is to say that the probability that a particle will use up all the information it can is 100%:

$$\sum_{p=0}^{N} f_{pn} = 1 \quad (12)$$

And we can write our equation (10), by using (11), as:

$$\Delta i^n / i^n = k \times \sum_{a=0}^{N} \left(f_{an} \times v_{an} \right) \quad (13)$$

This is nice. It tells us in a very simple way this: relative change of information processed by a particle is proportional to the product of information influence and relative speed of all particles. It makes sense: if avatars of all particles are the information network in which everything swims, then the intensity of processing depends on the number and relative speed of those avatars.

So the throughput of information processing is now, from equations (9) and (13):

$$\widetilde{T}^n=\sqrt{\widetilde{i}_p^n\times\widetilde{i}_c^n}=\sqrt{(i^n+\Delta i^n)\times(i^n-\Delta i^n)}=i^n\sqrt{1-\left(k\times\sum_{a=0}^{N}(f_{an}\times v_{an})\right)^2} \quad (14)$$

What is this throughput anyway? It represents the number of avatar pairs processed in a unit of time. Remember, avatars from previous and current moment in time combine to produce pairs – and those pairs determine what particle does – which is to move.

It is reasonable to assume that the number of pairings when all particles are at rest is the base throughput. This *base throughput is minimum necessary for particle to do something*. Anything less than the base throughput, and particle will simply wait for throughput to reach this base level.

So we can now express the throughput in terms of a base one:

$$\widetilde{T}^n/\widetilde{T}_0^n=\sqrt{1-\left(k\times\sum_{a=0}^{N}(f_{an}\times v_{an})\right)^2} \quad (15)$$

We can also present this equation in terms of how long a time it will take a particle to do the same thing. Clearly when particle does not have any extra information to process, it will perform its task the quickest. Or, the higher the throughput, the lower the time needed to do the task:

$$t_0^n/t^n=\sqrt{1-\left(k\times\sum_{p=0}^{N}(f_{pn}\times v_{pn})\right)^2} \quad (16)$$

or upside down:

$$t^n=\frac{t_0^n}{\sqrt{1-\left(k\times\sum_{a=0}^{N}(f_{an}\times v_{an})\right)^2}} \quad (17)$$

This is the mathematical expression for how slower a particle will perform its task when there is relative motion. A special case is of a small object near an isolated large one. Let large object be p and small object be n. Information influence of a large object on small object is:

$$f_{pn}=\frac{i^p/d_{pn}^2}{i^p/d_{pn}^2+i^n/d_{nn}^2} \quad (18)$$

In here, d_{nn} is the distance of object n to itself, which is always 1. This is clear if you consider that any object has all of its own information available to itself. So:

$$f_{pn}=\frac{i^p/d_{pn}^2}{i^p/d_{pn}^2+i^n}=\frac{1}{1+\frac{i^n}{i^p}\times d_{pn}^2} \quad (19)$$

Here we assume large object is so huge (i.e. $\frac{i^n}{i^p}$ is so small) that the above expression is:

$$f_{pn}\approx\frac{1}{1+0}=1 \quad (20)$$

Then the above equation (17) for how slow the particle behaves moving relative to an isolated large object is, by using (20):

$$t^n=\frac{t_0^n}{\sqrt{1-k^2\times v_{pn}^2}} \quad (21)$$

Similarly, to find out how slow the large object behaves when moving relative to a small particle, we calculate the same from equation (18), just reverse indexes p and n :

$$f_{np} = \frac{i^n / d_{np}^2}{i^n / d_{np}^2 + i^p} = \frac{1}{1 + \frac{i^p}{i^n} \times d_{np}^2} \quad (22)$$

The assumption of large object being so huge is still true (i.e. $\frac{i^p}{i^n}$ is so huge), that the above expression becomes:

$$f_{pn} \approx \frac{1}{1+\infty} = 0 \quad (23)$$

and finally:

$$t^p = \frac{t_0^p}{\sqrt{1-0}} = t^p \quad (24)$$

which says that large object will not behave any slower.
The above is a scenario of a small object moving relative to Earth. In this context, "small" object can be an electron or a jumbo jet, it won't make much difference. The above says an electron (or a jumbo jet) will slow down its behavior, and Earth won't.
What is constant k ? We can figure that out if we assume that speed of a particle is so high (we will denote it as V) that its processing of information slows down to zero, meaning it takes infinity to do anything, from equation (21):

$$t^n = \frac{t_0^n}{\sqrt{1 - k^2 \times V_{pn}^2}} = \infty \quad (25)$$

For this to be true, it must be that $1 - k^2 \times V_{pn}^2 = 0$ and clearly:

$$k = \frac{1}{V_{pn}} \quad (26)$$

So constant k is the inverse of the maximum speed that a small particle can achieve near a large isolated body. Since this speed is apparently a constant, we call it c :

$$k = \frac{1}{c} \quad (27)$$

and the equation for how slow particle behaves when moving relative to large isolated object is now, from equations (21) and (27):

$$t^n = \frac{t_0^n}{\sqrt{1 - \frac{v_{pn}^2}{c^2}}} \quad (28)$$

From this, we see that a consequence of informational premise is that the behavior of a particle slows down in motion, and also that there must be a speed limit. Speed limit must exist because when it takes infinity to process information, it takes infinity to change speed, so the speed tops out.
So far we didn't talk about whether avatars themselves move. Our hypothesis is they exist around a particle, and move *with* the particle, but do they move *relative* to the particle? They have to move. Why? Because *any point in space should have equal chance to host an avatar*. Otherwise, some point in space would have 100% chance of holding information, while many other points would be squarely 0%. Thus, *avatars must move in a fashion to afford every point at the same distance from a particle the same chance of hosting an avatar*.
If avatars move, that's the same as if a particle moves. So then, even if particles are at rest, they will behave slower, i.e. they will perform their tasks slower than if avatars didn't move. How much slower?
To find out, we will use a little trick. We will assume that avatars do not move, but particles are moving apart at some speed, all the way to infinity. By finding this equivalent speed at any given distance, we can figure this out.
We start from the basic equation (13) we have for extra information when particles move:

$$\Delta i^n / i^n = k \times \sum_{a=0}^{N} (f_{an} \times v_{an})$$

In case of two isolated particles (meaning $N=2$):

$$\Delta i^n / i^n = k \times (f_{pn} \times v_{pn} + f_{nn} \times v_{nn}) \quad (29)$$

and knowing that $v_{nn}=0$, i.e. the speed of particle relative to itself is always zero, and also putting in our speed c from equation (27):

$$\Delta i^n / i^n = f_{pn} \times \frac{v_{pn}}{c} \quad (30)$$

So here, v_{pn} is the equivalent speed at some distance d_{pn} that makes the slowing effect the same as do moving avatars.

Before we continue, let's make some obvious observations:

#1, the more information each particle has, the more avatars their will be in space around them.

#2, the longer the time period, the more extra information from avatars there will be.

#3, the greater the distance between particles, the less avatars they will see from each other.

Let's focus on #3 here. If particles move apart by a small distance $d(d_{pn})$ (meaning distance d_{pn} between increases a bit), that's the same as if the equivalent speed between them decreased by a bit of $d(v_{pn})$. So the change of information is, if we assume information influence f_{pn} is constant:

$$d(\Delta i^n / i^n) = f_{pn} \times d \frac{(v_{pn})}{c} \quad (31)$$

Now let's go back to #1 and #2 above. From those assumptions, the change of extra information from distance d_{pn} to distance $d_{pn} + d(d_{pn})$ should be:

$$d(\Delta i^n / i^n) = -w \times f_{pn} \times i^p \times \frac{1}{d_{pn}^2} \times dt \quad (32)$$

What does this equation say?

In here, we say there is some constant w , then we say that the more avatars there is from i^p and the higher information influence of p on n is, the greater the change will be, and the greater time period dt is, the more avatars will be seen, and finally that the further away from particle p we are, the less avatars there are (this is the inverse square of distance).

We need to find the speed v_{pn} so that the above two equations amount to the same thing.

By equating the two, we have:

$$d(\Delta i^n / i^n) = -w \times f_{pn} \times i^p \times \frac{1}{d_{pn}^2} \times dt = f_{pn} \times d \frac{(v_{pn})}{c} \quad (33)$$

In here, we can take advantage from knowing that trivial equation holds (i.e. distance equals speed multiplied by time):

$$d(d_{pn}) = v_{pn} \times dt \quad (34)$$

so we have:

$$-w \times f_{pn} \times i^p \times \frac{1}{d_{pn}^2} \times d(d_{pn}) = f_{pn} \times v_{pn} \times d \frac{(v_{pn})}{c} \quad (35)$$

Our idea was to move from distance d_{pn} to infinity, and the relative speed then declines to zero, so we can integrate:

$$-w \times i^p \times \int_{d_{pn}}^{\infty} \frac{1}{d_{pn}^2} \times d(d_{pn}) = \int_{v}^{0} v_{pn} \times d \frac{(v_{pn})}{c} \quad (36)$$

This is trivial, giving us:

$$-w \times i^p \times \frac{1}{d_{pn}} = -\frac{v^2}{2 \times c} \quad (37)$$

And so the equivalent speed v that makes for the same slower behavior as motion of avatars does, is:

$$v=\sqrt{w\times\frac{2\times i^p\times c}{d_{pn}}} \quad (38)$$

Putting that in equation (28) for particle's slowing when we have relative speed:

$$t^n=\frac{t_0^n}{\sqrt{1-\frac{2\times w\times i^p\times c}{d_{pn}\times c^2}}} \quad (39)$$

Since both w and c are constants, we shorten their multiplication to $G=w\times c$:

$$t^n=\frac{t_0^n}{\sqrt{1-\frac{2\times G\times i^p}{d_{pn}\times c^2}}} \quad (40)$$

This means a particle n at rest at distance d_{pn} from particle p will perform tasks slower in accordance to the above equation.

If processing of information drives change of motion, then we'll assume that processing power of a particle has limits. Put differently, after performing certain number of information pairings, a particle will be spent. Its information will still be seen by other particles, but it won't do anything anymore.

For that reason, we can also assume that a particle will try to spend less of its processing power. One way to do that is try and move closer to other particles, permanently. The reason for this is simple from above equation: particles perform less work when closer together, or in other words, everything they do is slower, buying time.

To calculate how would particles "huddle" together to reduce their informational footprint, we will investigate if this "huddling" motion can cost nothing in terms of informational throughput. If you consider what our little "trick" above is, you'll realize it is the exact same thing.

So, the equation for how exactly particles "huddle" together can be easily obtained from above. We will simply divide that equation (35) by dt (i.e. a small interval of time):

$$\frac{-w\times f_{pn}\times i^p\times\frac{1}{d_{pn}^2}\times d(d_{pn})}{dt}=\frac{f_{pn}\times v_{pn}\times d\frac{(v_{pn})}{c}}{dt} \quad (41)$$

and knowing that speed is simply distance over time $v_{pn}=\frac{d(d_{pn})}{dt}$:

$$-w\times f_{pn}\times i^p\times\frac{1}{d_{pn}^2}\times v_{pn}=\frac{1}{c}\times f_{pn}\times v_{pn}\times\frac{d(v_{pn})}{dt} \quad (42)$$

and we get this:

$$\frac{-w\times c\times i^p}{d_{pn}^2}=\frac{d(v_{pn})}{dt} \quad (43)$$

By using our previous convention $G=w\times c$, we get:

$$\frac{d(v_{pn})}{dt}=\frac{-G\times i^p}{d_{pn}^2} \quad (44)$$

Since this is the law of gravity, it has to be, in proper set of constants, that *particle's information is equal to rest mass*:

$$m_0^p=i^p \quad (45)$$

and our constant G is indeed the gravitational constant.

This means our previous equation (40) becomes:

$$t^n=\frac{t_0^n}{\sqrt{1-\frac{2\times G\times m_0^p}{d_{pn}\times c^2}}} \quad (46)$$

This is also a known result. It also means the *constant* c *we derived is indeed the speed of light as measured on Earth*.
Our equation (17):

$$t^n = \frac{t_0^n}{\sqrt{1-(k\times\sum_{a=0}^{N}(f_{an}\times v_{an}))^2}}$$

however, isn't exactly the same as expected, except when a small mass moves relative to a large mass. In general though, we predict that *the kinematic time dilation is a N-body problem*. More importantly, we predict that *kinematic time dilation involves mass and distance too*, in general, except in the case of an isolated large mass (like Earth).
When a sizable mass i^n moves at high speed away from large mass i^p, meaning their distance d_{pn} becomes huge, we have from equation (19):

$$f_{pn} = \frac{i^p/d_{pn}^2}{i^p/d_{pn}^2 + i^n} = \frac{1}{1+\frac{i^n}{i^p}\times d_{pn}^2} \approx 0 \quad (47)$$

and for a 2-body model (ignoring the rest of the Universe):

$$t^n = \frac{t_0^n}{\sqrt{1-(k\times(0\times v_{an}))^2}} = t_0^n \quad (48)$$

What this means is that kinematic time dilation declines with distance, and this is detectable *only with large mass away from isolated large bodies*. This is the new result of this hypothesis.

A recap is in order.

We have derived known results, namely kinematic and gravitational time dilation, and the law of gravity.

We have also *deduced* that the speed of light must exist, as well as gravitational mass.

We also deduced that quantum behavior must exist.

We only started with the notion of information processing on a fundamental level.

This is what this hypothesis is: a fundamental informational assumption before the first principles of physics.
The new result can be tested this way: build a space probe of sizable mass and shoot it out, away from Earth, on a trajectory that takes it far away from other planets. *This is the opposite of what our probes currently do*. Once away enough from Earth, the clock on this probe will *no longer slow down* even as its speed relative to Earth increases. This is the opposite of what we would expect for this probe to happen. If this probe accelerated further, it could reach the nearest star with its clock not so far away from our own.
Further more, from above equation (48), the speed of the probe will still have an upper limit, but it will be higher than c, which holds only for a small body nearby a large body. Maximum speed is when time dilation approaches infinity, so from equation (48) we can get the maximum speed V_{an}:

$$k\times 0\times V_{an} = 1 \quad (49)$$

and

$$V_{an} \rightarrow \infty \quad (50)$$

Basically, the deeper the space, the higher the speed limit. It can be many times over c.

Conclusion

The conclusion is that informational hypothesis may be a viable one, in two ways: firstly, it derives known physics without a circular argument, and secondly, it predicts new results for an experiment we think would happen otherwise, namely the above space probe experiment. If true, one conclusion may be that the physics of deep space may be broader of what we know of here on Earth.
After all, telescopes observing deep space can tell only so much. Every anomaly we see in the sky tends to be explained by means of existing theories with new tweaks, which increases complexity of those existing theories. Maybe it's better to simplify instead with a new theory?