On the information content of physical matter

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August 26, 2014

Abstract: Physical matter has certain apparent information content. We explore here the amount and the role of this information content. The method of doing so will minimize the role of presently known laws of physics, in order to explore the effects of information content alone, and thus avoid potentially isomorphic conclusions.

Keywords: information, nature of matter, relativity, gravity, quantum effects.

Information and physical matter

Physical particles contain information. However, we do not have a clear answer as to the amount of such information content and its exact role. Whatever its role is, we should say for certain that it does not exist in order to be accounted for by observers, but rather we consider it to be fundamental in determining its state of motion. We start with:

Postulate I: *Every physical particle uses information to change the state of motion, i.e. to accelerate.*

Generic use of information

Information is always a set of facts. To use information, there has to be more than one set of facts, one applied against the other. In a simplest scenario, there are two sets of facts (with A and B number of facts). In this case, use of information means interaction of all facts from one set with all from the other, wherein each fact from one set is paired with each fact from the other. Thus, the number of fact pairs being used in this interaction in order to exhaust all possibilities is $A \times B$.

Physical matter as information container

The information content a physical particle possesses is *self-information*. We do not think, as a reasonable physical assumption, that the amount of information a physical particle has, can be infinite. By the same token, usage of information by physical matter must have physical origins, and thus, it must have physical resources, and we think of all such resources of information usage to be finite. Hence we have:

Postulate II: *Resources for information use within a physical particle are finite.*

For information use, there are a few obvious physical resources necessary for such usage: the physical encapsulation of information, i.e. information storage, and the throughput of using information, i.e. the rate of interaction of facts per unit of time.

Physical Space and Time

We start with flat *N*-dimensional space, where *N*, for now, can be any non-zero positive integer. There is no absolute space and *all motion is considered relative*. Time is considered *absolute for the usage of information by physical particles only, and for nothing else, with no requirement of observable simultaneity*, because the use of information by physical particles is, by definition, unobservable. Only the behavior of physical particles, as a result of their information use, is observable, while the actual information use cannot be. Otherwise, information used by physical particles would not be fundamental, but rather a consequence of information use by sub-particles, with such process of subdivision of physical matter continuing *ad infinitum*, leading to infinite notions that we specifically consider unrealistic. The notion of time, which is absolute solely with respect to information use by physical particles, is *information time.* All information use happens in information time. We will use the term "time" to denote information time, unless otherwise noted, with the understanding that information time cannot be measured, even in principle. However, the direct consequences of a physical process of information use, are observable.

Physical embodiment of information

An elementary particle originates in a given location in space and we consider it a small finite sphere. The particle's self-information originates in the same spatial position. We consider the two to be separate physical entities that share the same originating location. By *"elementary particle"* we mean that its motion is inseparable from the motion of its self-information. We consider physical space to have no preference for direction and no preference for scale when it comes to information content of matter.

No directional preference for information of matter means that facts comprising such information are randomly spread in all directions on a particle surface. Since information consists of a finite number of facts, we can only say that every point on the particle's surface has equal chance to possess any given fact over a long period of time. The consequence of this is that a set of facts comprising information has to randomly change its position on the particle's surface every so often, in order for any point on this surface to have the same probability of having any given fact over a long period of time.

No scaling preference for information means that there is no scale, i.e. no absolute unit of measurement, for the physical space in which information content exists. In other words, if two sources of information are at some distance, we can imagine them being at double the distance, and if the size of those information sources doubled as well, there would not be any physical difference in the system itself, assuming no other sources exist. The consequence of this is that the same information content exists on many spheres around its location, aside from the sphere representing a particle. Since the density of such repetitive information in space has to be finite, we can say that the same information content exists on virtually every sphere centered in its location. Note that in the case of doubling the distance, we could consider doubling the size of the two particles too. However, we do not assume that a physical particle itself exists as "many spheres" around its location, because that would make an infinite number of particles originating in the same location, and for infinite required resources. The same requirement does not exist for information in physical space, since its density would never be infinite.

We can now formulate the following postulate:

Postulate III: *Information content originates in a specific location, existing on virtually every sphere around that location, with the position of every fact comprising such information randomly and periodically changing over time.*

Periodic change of location of every fact is *randomization of information content*, or just *randomization* for short. The period of time in which one randomization occurs is a *randomization interval*. The consequence of Postulate III is that the information content of a particle exists beyond the particle itself and is declining in density the same way as the surface of the sphere in N-dimensional space. The sum of information content in a given volume of space is available to any physical particle occupying that volume of space, and is called *spatial information content*, or just *spatial information* for short. According to Postulate I, physical particles use spatial information to change their state of motion, i.e. to accelerate.

Since a physical particle has finite resources for the usage of spatial information, only some facts from such information may be used, as determined by the resources of a particle. All facts from spatial information have an equal chance to be used. A particle spends some finite period of time to collect the spatial information before it uses it. We assume this finite period of time to be fixed and short, and equal to the time it takes to use spatial information. In this way, both usage and collection of spatial information happen continuously in time. This finite period of time in which spatial information is collected and in which the previously collected one is used, is a *spatial information usage cycle*, or just *information cycle* for short.

A particle collects all possible spatial information in the physical location through which it moves. This means, in addition to collecting such information anew every time its usage has been completed, a particle also collects spatial information anytime it changes. Between the two, with respect to the finite resource a particle possesses, this represents all possible spatial information it can use. For example, if a particle moves, it goes from one location to another in succession. Every time spatial information changes from location to location, the new facts from this information are collected. As another example, whenever randomization of spatial information happens, there is a change of such information in whatever location a particle is, and consequently, new information from it is collected. We sum this up in a more general statement:

Postulate IV: *Physical particle collects maximum possible spatial information content.*

Because finite information is always a finite collection of indivisible facts, spatial information, by definition, is a *discrete scalar physical field* that exists around every physical particle.

Relativity

Only the nominal notion of relativity will suffice. Since information use by physical particles is not observable, only the notion of equality in a local reference frame, in information time, is possible, and thus, we cannot, even in principle invoke any version of relativity that relies on external observers. We have:

Nominal relativity: *Laws of information usage by an elementary physical particle are to be the same in its local frame of reference only, and only in information time, regardless of such frame of reference accelerating or moving uniformly.*

The reason for using verbiage in the form of *"are to be"* when expressing the equality of local frames of reference, is to emphasize that the sameness in which all particles use information, is not observable by the definition of particle’s information use, and not by our proclamation. We cannot observe such sameness, but rather examine its direct consequences, much as it is in the accepted formulation of the concept of Relativity[7].

Nominal relativity effectively reduces the principal place where laws of Nature are the same to a small local space in which an elementary physical particle exists, while other frames of reference, such as those of external observers, are not considered foundational for the purpose of formulating the fundamental physical laws. We consider laws of Nature to be the same as laws of information use by elementary particles.

Dimensionality of physical space

Physical space can have any number of dimensions to begin with. However, consider a physical particle departing another particle, with no other spatial information present anywhere else. We can reasonably assume that infinitely far away, for any arbitrary duration of information cycle, the probability for a particle to use the spatial information content of the other particle, will approach zero. Thus, as a particle moves away, the amount of spatial information collected from the other particle on its journey to infinity, has to be finite, i.e. it has to converge. If it does not, there could always be a finite period of time in which the spatial information collected from the other particle would be arbitrarily large. If the duration of information cycle is made equal to this finite period of time, a particle will, statistically, always use the arbitrary substantial spatial information of the other particle, even infinitely far away. There are many ways to express the amount of information collected like this, but they all reduce to the following simple integral expression, with the density of the spatial information at distance x over the surface of a sphere in N-dimensional space being summed up, as it is in the aforementioned journey of a particle to infinity:

$$\int_R^\infty \left(x^{N-1}\right)^{-1} dx$$

The above sum will converge for any $N>2$. The number of spatial dimensions must be greater than two, i.e. it could be 3, 4, 5 etc. Per Postulate IV, a particle would collect maximum possible amount of spatial information. For a particle to collect the *finite and maximum* amount of spatial information, in the scenario we're considering, we will be looking for the solution to the following, where N is an integer variable:

$$\max\left[\int_R^{\infty}\left(x^{N-1}\right)^{-1}dx\right]$$

The trivial solution for the above is $N=3$. Hence, the number of spatial dimensions must be three.

The density of spatial information

Since finite information always consists of finite number of facts, the number of facts in spatial information, at some distance from a particle, according to Postulate III, and for three-dimensional space, is:

$$i_R = a \times i / R^2 \quad (1)$$

i_R is the average number of facts at distance R from a particle in some small volume of space; i is the self-information of a particle; a is a dimensional constant. For simplicity, we henceforth omit a, and use only the dimensionless value R in further text. Since the particle's self-information is present within the same volume as the particle is, the minimum value for R has to be the length of an elementary particle.

Usage of spatial information

A particle relying only on spatial information to exhibit directional motion towards, or away from, other particles, can do so only if it retains spatial information from the past. Because spatial information is a scalar field, it is impossible to move radially with respect to another particle just by using its spatial information from a single location. Spatial information from at least two locations in space must be used in order to move towards, or away from, a particle which originated such spatial information. This means that every physical particle, assuming it interacts with other particles, must retain spatial information from at least one moment prior, in the simplest scenario, i.e. we are not considering retaining information from three or more moments in time.

For example, a physical particle collects spatial information in successive moments t_1 and t_2, and then uses them both in the following moment t_3. Similarly, the spatial information collected in successive moments t_2 and t_3 is used in the following moment t_4, etc. The spatial information from moments t_1 and t_2 are the *previous and current spatial information*, respectively, or just *previous and current information* for short, for the usage in moment t_3. Information use by a physical particle unwinds by collecting previous and current spatial information in two consecutive information cycles, and using them in the following one. In each cycle that follows, current spatial information, by definition, becomes the previous one. In every moment in time, then, there is always previous and current spatial information available, and the use of such information happens continuously in time. This is the only way in which spatial information *is always collected and always used*, per Postulate IV. Hence we can have:

Postulate V: *Physical matter retains spatial information from the previous and current information cycle, and uses both in the following cycle.*

Since the throughput of information use is finite, there is a delay between the moments in which a particle uses the two sets of spatial information. Thus, the result of information use by a physical particle is a discrete event in time, and so the acceleration in general must be a discrete event in time.

If a particle is infinitely far from other particles, its own self-information is the only spatial information available to it. Thus, the minimal size of information storage a particle must have for previous and current spatial information must be equal to the size of its self-information. This size of information storage is the particle's *information capacity*.

The amount of spatial information collected by a particle

From Postulate IV, a particle collects spatial information every time it changes, in addition to whenever it has already been used in a preceding information cycle, i.e. in addition to the beginning of each information cycle.

When a *particle moves* relative to another particle, it visits additional locations, and collects more spatial information. If its relative speed doubles, it will visit twice as many locations. Thus, the amount of additional information collected is proportional to the relative speed of two particles.

When *particles are at rest*, randomization presents new spatial information, once per randomization interval. The higher the spatial information at a location, the more additional information is collected through its randomization. We can say qualitatively that, because spatial information declines with the square of distance from a particle, the closer a particle is and the more information content it has, the more its spatial information is changing because of randomization, and the more is collected by other particles.

The additional spatial information collected, either due to motion or randomization, is *additional spatial information*, or just *additional information* for short. Additional information due to relative motion is M-additional information, and due to randomization is R-additional information.

The throughput of information use of a physical particle

If a particle's information capacity is *A* number of facts, then by using the previous and current spatial information, there is an interaction of $A \times A$ pairs of facts. The collection of fact pairs in which each fact from one set has interacted with each fact from another, is an *interaction information set*, or just *interaction set*. The actual throughput of current spatial information is *A*, because that is the amount of such spatial information collected during the information cycle. This means that the throughput of spatial information is the square root of the size of interaction set, if a unit of time is the duration of an information cycle:

$$T_A = \sqrt{A \times A}$$

The throughput of current spatial information determines at what moments in time a particle changes its state of motion. If there is an interaction between two information sets of different sizes (*A* and *B*, for example), the throughput is:

$$T_{AB} = \sqrt{A \times B} \quad (2)$$

This is because the resulting interaction set has no information attached to it as to how it was created. A set of 36 fact pairs can be produced by the interaction of two sets of sizes 6 and 6, but it can also be produced by the interaction of two sets of sizes 2 and 18 (6×6=2×18=36). Two equal-sized interaction sets must produce the same information throughput, and we already know what this throughput is, when both sets are equal.

Repeated information interaction (i.e. usage) of the same two sets of facts produces the same interaction set, and the same result.

Any pair of facts in the interaction set can be produced at the same time as any other pair, because no fact in either previous or current set depends on any other fact. Thus, all fact interactions would happen at the same time. For that reason, the information interaction of 1 pair of facts takes the same time as it does for 100 pairs of facts. Because an information cycle is the time in which information interaction takes place, an *information cycle always takes the same time, regardless of the amount of spatial information used*.

The relevance of spatial information to physical particles

The spatial information at a location of particle *k* comes from all particles and is, from Eq. (1):

$$I_k = \sum_{j=1}^{U} i_j / R_{jk}^2$$

where U is the number of all particles, anywhere in existence; i_j is the information capacity of some particle j; R_{jk} is the distance from particle k to j.

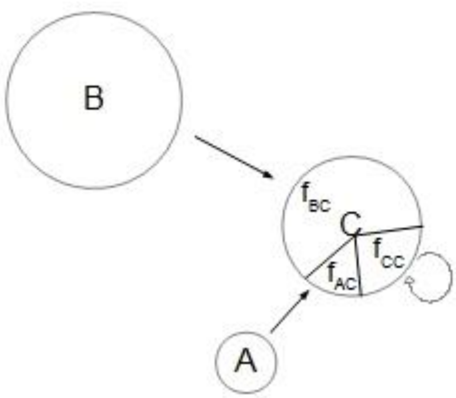
Since all facts from the spatial information have the same probability to be used by a particle, we can say that the percentage of k's resources allotted for spatial information of some particle m is:

$$f_{mk} = \left(i_m / R_{mk}^2 \right) \Big/ \sum_{j=1}^{U} i_j / R_{jk}^2 \qquad (3)$$

This percentage is *spatial information influence of m at k*, or just information influence for short. By definition, the sum of all information influences on a particle is exactly 1:

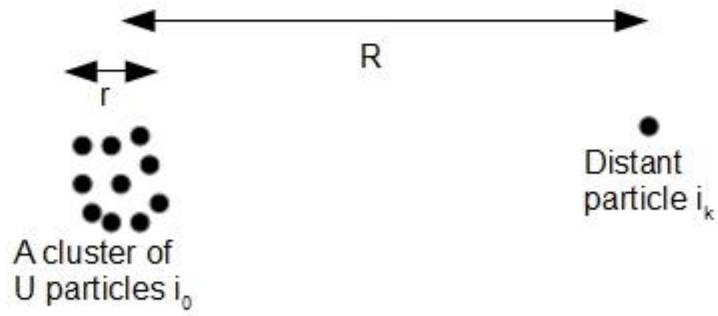
$$\sum_{j=1}^{U} f_{jk} = 1$$

An example of three sources of spatial information (the size indicating information capacity) is shown below. Information influence of each of (*A*, *B* and *C*) on *C* is shown, assuming the area representing *C* is unity, f_{AC} being influence of *A* on *C*, f_{BC} being influence of *B* on *C*, and f_{CC} being influence of *C* on itself.



Isolated large group of particles

A number of distant elementary particles grouped closely together is a *cluster*:



From the viewpoint of a distant particle *k*, a cluster can be approximated as an elementary particle represented by the sum of its spatial information:

$$I_k \approx \frac{\sum_{j=1}^{U} i_j}{R^2}$$

where U is the number of elementary particles in a cluster far away from *k*, and I_k is the spatial information of a cluster at the location of *k*.

The information influence of distant particle *k* on any of the identical elementary particles *d* comprising the cluster is:

$$f_{kd} = \frac{i_k / R^2}{\sum_{j=1}^{U} i_j / r_{jd}{}^2 + i_k / R^2}$$

$$\approx \frac{i_k / R^2}{U \times i_0 / r^2 + i_k / R^2}$$

Where i_0 is the information capacity of any elementary particle within a cluster, including *d*, and *r* is some distance used to approximate all distances in the cluster where $r << R$. Because of that, and because we assume U to be much greater than 1, it apparently holds that spatial information of a cluster itself, at its location, is much greater than that of particle *k*:

$$i_k / R^2 << U \times i_0 / r^2$$

If we consider two clusters, with U_1 and U_2 particles, then we can compare the influence of particle *k* on any elementary particle from the first cluster, versus on an elementary particle from the second cluster:

$$\frac{f_{k2}}{f_{k1}} \approx \frac{i_0 / R^2 \times (U_2 \times i_0 / r^2 + i_k / R^2)}{i_0 / R^2 \times (U_1 \times i_0 / r^2 + i_k / R^2)} \approx \frac{U_2}{U_1} \quad (4)$$

This means the information influence of a distant particle *k* on any particle in a cluster is reversely proportional to the size of a cluster.

The relevance of a physical particle

In *N* information cycles of particle *k* (where *N* is statistically large) the amount of spatial information from any particle *m*, that is actually used, is approximately:

$$N \times i_k \times f_{mk}$$

Here, i_k is the information capacity of particle *k*, which is used to collect spatial information. The meaning of information influence is statistical, because all facts in spatial information have equal chance to be collected. Hence, the amount of spatial information actually used by a particle can be specified only in terms of probabilities, and with a large number of information cycles.

Since number of facts in any information is an integer, the above number has to amount to an integer greater than zero, in order for particle *m* to contribute any spatial information to *k*, during *N* information cycles. If the information influence of *m* at *k*, i.e. f_{mk} , is small, chances are it will not contribute any spatial information in a good number of information cycles. Thus, for any given period of time, there will exist a number of particles that will contribute *no* spatial information to *k*, and will not have any direct information influence at all on *k*, and as such are effectively irrelevant to *k*. A group of particles that have *nonzero* information influence on *k* is called the *constraint group of k*. Only a constraint group is relevant to a particle at any moment in time. As a particle moves, its constraint group will generally change and will contain different particles over time. The value of f_{mk} is, thus, considered non-zero, only if a particle belongs to the constraint group of *k*, *otherwise it is zero*. This is an important implicit caveat for our usage of information influence in all equations.

If *m* alone comprises the constraint group of *k*, then from Eq. (3) we have:

$$f_{mk} \approx 1 \Big/ \left[1 + (i_k \, / \, i_m) \times R_{mk}^2 \, / \, R_{kk}^2 \right]$$

If *m* is large and close, then it is $f_{mk}\approx 1$. When *m* is small and far away, then it is $f_{mk}\approx 0$. Small clusters are overwhelmed by the spatial information from nearby large clusters, and large clusters are underwhelmed by the small ones. In general, for a particle to be the part of a constraint group, we have to include its additional information as well (due to M- and R-additional information), so the total amount of spatial information from particle *m* at location of *k* is, during *N* information cycles:

$$N \times (i_k \times f_{mk} + \Delta i_{km})$$

where Δi_{km} is the additional information of particle *k* that originates from particle *m*, due to both relative motion and randomization of *m*.

The effect of relative motion on spatial information

If particle *n* moves relative to *m*, the number of locations in space that contain spatial information of *m* which are visited during an information cycle, will be proportional to their relative speed, and so will be the amount of M-additional information. A nearby particle *q* which is at rest relative to *m* will not collect this additional spatial information.

Thus the M-additional information of *n* is proportional to its speed relative to *m*:

$$\Delta i_n \, / \, i_n = s \times v_{mn} \times f_{mn} \quad (5)$$

where Δi_n is the M-additional information of *n* resulting from the movement relative to *m*; i_n is the information capacity of particle *n*; *s* is a dimensional constant of proportion; f_{mn} is the information-influence of *m* at *n*; v_{mn} is the relative speed of *m* and *n* achieved where f_{mn} can be considered constant.

The exact equation for Δi_n would include all particles relative to which *n* is in the state of motion. We have, where *U* is the number of all particles in motion relative to particle *n*:

$$\Delta i_n / i_n = s \times \sum_{j=1}^{U} v_{jn} \times f_{jn} \quad (6)$$

The sum in above equation is a single number that is *not relative to any frame of reference*, i.e. it is a fixed value for a particle at a given moment in time. It is an *information speed of a particle*:

$$v = \sum_{j=1}^{U} v_{jn} \times f_{jn} \quad (7)$$

And we can write simply:

$$\Delta i_n / i_n = s \times v \quad (8)$$

Information speed is not relative to any frame of reference, as it shouldn't be according to our acceptance and use of nominal relativity alone. Rather it depends on relative speeds and information influence of, at most, all other particles in existence. As such, the same information speed does not mean any particular speeds relative to other particles. Information speed is a fundamental characteristic of the usage of spatial information, and not of motion *per se*. Even particles at rest have a certain information speed, because of R-additional information, for which we will account in a subsequent chapter.

Note that Δi cannot become greater than i because additional information (either M or R) has to fit in the finite information capacity of a particle:

$$\Delta i_n \leq i_n \quad (9)$$

Physical particle as a finite information container

Let Δt be the duration of information cycle. The particle's information capacity is finite and does not change. Δi denotes the amount of additional spatial information collected during the period Δt (both M- and R-additional information). The only way this additional spatial information can be used is if some of the previously collected information is discarded, at random.

We can express mathematically Postulate V as follows, to say that a particle retains two sets of spatial information, previous and current, and that by definition what was the current information in a moment ago is now a previous one:

$$i_{\mathrm{p}}(t) = i_{\mathrm{c}}(t - \Delta t) = i$$

Where i_p is the size of the previous information set and i_c is the size of the current one, each equal to i, which is the information capacity of a particle. Additional spatial information (due to motion or randomization) belongs in the current information. Since the resources of a particle cannot expand, some of the facts already in the previous information must be discarded, randomly. We can write that, in terms of occupying the finite resources of a particle, that current information will expand, and previous information will shrink:

$$i_{\mathrm{p}}(t + \Delta t) = i_{\mathrm{p}}(t) - \Delta i = i - \Delta i$$

$$i_c(t + \Delta t) = i_c(t) + \Delta i = i + \Delta i$$

To state that the resources of a particle are finite, we can write:

$$i_c(t) + i_{\mathrm{p}}(t) = i + i = (i + \Delta i) + (i - \Delta i) =$$

$$i_c(t + \Delta t) + i_{\mathrm{p}}(t + \Delta t)$$

The amount of spatial information used by a particle

During the information cycle, which is of fixed and small duration, and when there is no additional spatial information (that is $\Delta i=0$), the size of interaction set used for previous and current information is, where i is the information capacity of a particle:

$$H_0 = i \times i = i^2 \quad (10)$$

In the case when there is additional information ($\Delta i>0$), we have:

$$H = (i - \Delta i) \times (i + \Delta i) = i^2 - (\Delta i)^2 \quad (11)$$

The part of interaction set which is lost, is the difference between the two, i.e. Δi^2. Because of this information loss, *the result of spatial information use by a physical particle is generally unpredictable*, even if a particle is guaranteed to collect the exact same spatial information, and even if the use of the same spatial information always produces the same result. *The change of motion of physical matter is not deterministic*.

The throughput of spatial information in a particle

We will use Eq. (2) to derive the throughput of spatial information use of a particle. The throughput of information use T is, when there is no additional spatial information, i.e. when $\Delta i=0$, from Eq. (10):

$$T_0 = \sqrt{i \times i} / \Delta t = i / \Delta t$$

Where Δt is the duration of information cycle and i is the information capacity of a particle.

The throughput when there is additional spatial information, i.e. when $\Delta i>0$, from Eq. (11):

$$T = \sqrt{(i - \Delta i) \times (i + \Delta i)} / \Delta t = \sqrt{i^2 - (\Delta i)^2} / \Delta t \quad (12)$$

or:

$$T = T_0 \times \sqrt{1 - (\Delta i)^2 / i^2}$$

For example, if the information capacity of a particle is 20, it means that the size of previous information is 20, and the same for current information. When there is no M- or R-additional information, i.e. when particle is infinitely far away from other particles, its throughput of information use is the square root of 20×20, or 20 per information cycle, which is what we expect. Suppose there is additional information of 2 facts per information cycle, for instance because a particle moves relative to other nearby particles. Due to this additional information, the throughput would now be the square root of (20+2)×(20-2), or approximately 19.89 per information cycle. The equations we derived, and this example, are a mathematical expression of an intuitive conclusion that the use of information content by a particle must be slower when there is more spatial information than there are resources to use it.

Moments in time when a particle cannot accelerate

The dimensional constant *s* in Eq. (6) has to be an inverse of speed, from a simple dimensional analysis. Consider that additional information cannot be greater than the information capacity of a particle, or from Eq. (9):

$$\max(\Delta i_n / i_n) = 1 \quad (13)$$

From Eq. (8), we can write:

$$\max(\Delta i_n / i_n) = 1 = \max(s \times v)$$

or:

$$\max(v) = \frac{1}{s}$$

Or if we substitute *1/s* with a new constant *c*:

$$s = 1 / c \quad (14)$$

we have:

$$\max(v) = c \quad (15)$$

This result means that *the information speed of a physical particle has a limit, equal to constant c*. Let us remember that information speed is not relative to any frame of reference.

When the information speed of a particle approaches *c*, the throughput of its use of spatial information approaches zero, as evident from Eq. (12) and Eq. (13):

$$T = \sqrt{i_n^{\,2} - (\Delta i_n)^2} \Big/ \Delta t \approx 0 / \Delta t = 0$$

In a system of two isolated particles *m* and *n*, where *m* has much more information content then *n*, it will be $f_{mn} \approx 1$, and information influence of all other particles in existence will be practically zero. In this case, the information speed of a particle *n* is v_n, and from Eq. (7):

$$v_n = \sum_{j=1}^{U} v_{jn} \times f_{jn} \approx v_{mn} \times 1 = v_{mn} \quad (16)$$

Or, the information speed of particle *n* is approximately equal to the speed relative to a nearby large isolated information source *m*, which is v_{mn}. In this case, the maximum speed of *n* relative to *m* is equal to constant *c*, from Eq. (15) and the above Eq. (16):

$$\max(v_{mn}) = c \quad (17)$$

This means, nearby large isolated information source, the maximum attainable relative speed is equal to constant *c* regardless of what its initial speed was relative to this information source. To repeat our earlier conclusions, the reason why such maximum relative speed exists is because at that speed, the throughput of spatial information use of a particle converges to zero, and the change in motion converges to zero too. In other words, *a particle's ability to accelerate converges to zero*.

In general, the information speed limit is reached when the following is true, according to Eq. (7) and Eq. (15):

$$c = \sum_{j=1}^{U} v_{jn} \times f_{jn} \quad (18)$$

This above equation describes a particle that always moves as close to information speed of *c* as possible. In general, because information influences change with motion, so must the maximum relative speeds, in order for such a particle to remain at maximum information speed. This means that the maximum relative speeds are always local, i.e. they depend on information influences and relative motion of other particles, and can be lesser or greater than *c*. In the corner case we described, as in Eq. (17), local relative speed limit is practically constant and equal to *c*.

Note that, because spatial information is a discrete spatial scalar field, the density of spatial information in a small local area can be zero, while in a larger area it has some finite non-zero value. Because of that, the above limit on the relative speeds, in Eq. (18), is valid only for relatively larger areas, while *in smaller areas, the maximum relative speeds can be unlimited*. When talking about the maximum relative speeds, this is the caveat to keep in mind.

Kinematic time dilation

Change in motion of a particle is the result of use of spatial information. The throughput of spatial information use corresponds to the rate at which change in motion happens in time, and this is the rate at which any physical clock works. Thus, this rate is *physical time*, and is, by definition of a clock, the measured time for an observer in a local frame of reference. This is in contrast to information time, which cannot be measured, even in principle, and which corresponds to the throughput of spatial information use of a physical particle infinitely far away. In the case of such a particle, there is no additional information and the throughput of spatial information use is the fastest possible. Physical time, as measured by a clock, always unwinds slower than information time, if information time could be measured at the location of a particle infinitely far away.

Since the throughput of spatial information T can vary, the rate at which a physical clock ticks, will vary. When the additional information Δi varies, from Eq. (12), so does the throughput of information use by a particle:

$$T_1(t) = \sqrt{i^2 - (\Delta i_1)^2} \Big/ t \quad ,$$

$$T_2(t) = \sqrt{i^2 - (\Delta i_2)^2} \Big/ t \quad ,$$

$$T_1(t) \neq T_2(t) \quad .$$

Let dt_1 and dt_2 be small increments of physical time. Because the measurement of a local clock is, by definition, the same as the throughput of spatial information, this throughput is always the same in physical time:

$$T_1(dt_1) = T_2(dt_2)$$

We have:

$$\sqrt{i^2 - (\Delta i_1)^2} \Big/ dt_1 = \sqrt{i^2 - (\Delta i_2)^2} \Big/ dt_2$$

and

$$dt_1 = dt_2 \times \sqrt{i^2 - (\Delta i_1)^2} \Big/ \sqrt{i^2 - (\Delta i_2)^2}$$

From this and Eq. (8) and Eq. (14), we have:

$$dt_1 / dt_2 = \sqrt{\frac{1 - s^2 \times v_1^2}{1 - s^2 \times v_2^2}} = \sqrt{\frac{1 - v_1^2 / c^2}{1 - v_2^2 / c^2}} \quad (19)$$

dt_1 is a small physical time interval when particle's information speed is v_1, and dt_2 is a small physical time interval with information speed of v_2 .

This represents the general transformation of physical time. Note that *information time does no longer figure* in this equation, and we have now obtained a testable result.

Let us consider a situation of a small moving particle *n* near large isolated information source *m*. The information influence f_{mn} is nearly 1, and the information influence of all other particles is nearly zero. Let us have t_1 and t_2 such that the two are at rest ($v=0$) for a unit of physical time t_1, and the relative speed is uniform *v* for a unit of physical time t_2. In this latter case, the information speed of a particle *n* is equal to its speed *v* relative to *m*, from Eq. (16). Thus we can write:

$$v_1 = 0$$

$$v_2 = v$$

and from Eq. (19):

$$t_1 \approx t_2 \times \sqrt{\frac{1 - 0^2 / c^2}{1 - (v + 0)^2 / c^2}} = t_2 \Big/ \sqrt{1 - v^2 / c^2} \quad (20)$$

For a large information source *m*, the information influence of particle *n* is practically zero, i.e. $f_{nm} \approx 0$, hence the throughput of spatial information use will not change much for the large source *m*, and so from Eq. (7), we will have:

$$v_1 = 0$$
$$v_2 = 0$$

And it follows:

$$t_1 \approx t_2 \times \sqrt{(1 - 0^2 \ / \ c^2) \Big/ (1 - 0^2 \ / \ c^2)} = t_2$$

Suppose there is a small clock nearby a large planet. From the above, when in motion relative to the large planet, we see that the (physical) clock time will be slower, while the (physical) planet time will not be by much.

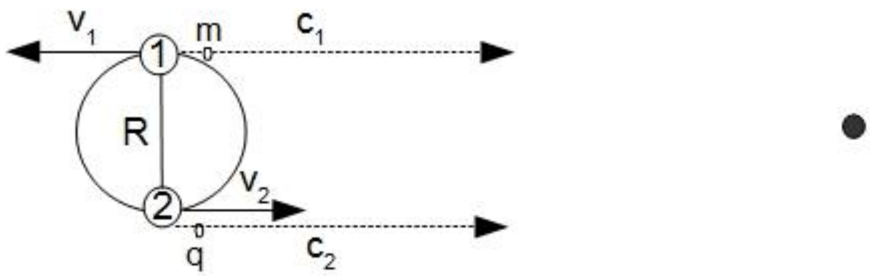
From these results, we can conclude that the constant c is very close to the speed of light measured on Earth, the location of which is, for our intents and purposes, an isolated large information source. A photon is a particle that always moves virtually at the information speed limit of c, which can mean a wide variety of relative maximum speeds, depending on the constraint group at any given location, except near large information sources, when the maximum speed of a photon is always c relative to a large information source. By definition, in this case, this maximum speed *will be so regardless of the speed of the emitter*. We can also say that a particle moving at information speed c is the fastest possible way to deliver *high* information influence to a faraway location. This is in contrast to particles anywhere having *some* information influence on other particles at *some* moments in time *only*, by means of their spatial information, as evident from Eq. (3).

The Michelson-Morley experiment

Since the speed of light near a large isolated information source is always c relative to this source, measuring the speed of light in different directions in a lab on Earth, relative to anything, must produce a null result. For this reason, the result of Michelson-Morley experiment has to be the same as it has been observed. However, there is also the Sun, the Moon and other nearby solar bodies, and they also comprise a photon's constraint group, albeit their information influence is much smaller. This means that the speed of a photon *is not c relative solely* to a ECEF (Earth-Centered-Earth-Fixed) frame of reference, in which the Michelson-Morley experiment is conducted, but it varies due to the influence of the Sun and the Moon, even with such influence being much smaller than that of Earth. The speed of a photon can be found from Eq. (18) by accounting for the mass of Earth, its radius, and masses of the Sun and the Moon and their distances to the photon, assuming the photon is traveling at sea level, and ignoring other celestial bodies. Note that because of the motion of these bodies that varies relative to us, such small variation in speed will vary in time.

The de Sitter effect

Two large isolated information sources (1) and (2) orbit one another at fairly high speeds v_1 and v_2 (speeds are shown relative to a distant observer on the right, represented by a black dot):



Since this is not the case of a single large isolated information source, the limiting case of Eq. (17) does not hold. We will calculate speeds c_1 and c_2 of photons *m* and *q* relative to a distant observer (small circle on the far right).

For a photon *m* emitted toward distant observer, Eq. (18) gives us, assuming axis *x* is in the direction toward the observer:

$$(c_1 + v_1) \times f_{1m} + (c_1 - v_2) \times f_{2m} = 1 / s$$

Similarly for photon *q*:

$$(c_2 + v_1) \times f_{1q} + (c_2 - v_2) \times f_{2q} = 1 / s$$

where f_{1m} is information influence of (1) on *m*, f_{2m} is information influence of (2) on *m*, f_{1q} is information influence of (1) on *q*, f_{2q} is information influence of (2) on *q*, c_1+v_1 is the relative speed between (1) and *m*, c_2-v_2 is the relative speed between (2) and *q*, c_2+v_1 is the relative speed between (1) and *q*, c_1-v_2 is the relative speed between (2) and *m*. Note that the above speeds, which are c_1+v_1, c_2-v_2, c_2+v_1 and c_1-v_2, from Eq. (18), and from the definition of information influence, are the speeds of photons relative to the two orbiting objects, where speeds c_1, c_2, v_1 and v_2 are the speeds relative to the distant observer on the right.

In this case it is $f_{1m} \approx 1$, $f_{2m} \approx 0$ and $f_{1q} \approx 0$, $f_{2q} \approx 1$:

$$c_1 = \frac{1}{s} - v_1 = c - v_1$$

$$c_2 = \frac{1}{s} + v_2 = c + v_2$$

In the vicinity of (1) and (2) the speed of a photon is dependent on the relative speeds of (1) and (2).

When the distances d_1 and d_2 of both photons away from (1) and (2) are sufficiently larger than R, which happens rather quickly due to the speed of photons, we have (assuming $d_1 \approx d_2$, $i_1 \approx i_2$, $i_q = i_m << i_1, v_1 \approx v_2$):

$$f_{1m} \approx \frac{i_1 / {d_1}^2}{i_m + i_1 / {d_1}^2 + i_2 / {d_2}^2}$$
$$= f_{1q} = f_{2m} = f_{2q} \approx 0.5$$

$$c_1 = c_2 = c + 0.5 \times (v_2 - v_1) \approx c$$

The photon speeds away from (1) and (2) become equal soon enough. Thus photons emitted from (1) and (2) will effectively take the same time to reach a distant observer. If (1) and (2) move away from a distant observer faster than c, a photon may still reach a distant observer, and after practically the same time, because away from (1) and (2), the information influence of (1) and (2) diminishes and the maximum local speed will be higher than c relative to (1) and (2), according to Eq. (18).

Relative speeds when approaching

If two particles approach each other at speeds higher than c, both particles must slow down as they get very close to one another, as the information influence on each other grows, and eventually they become each other's constraint group when they get much closer. Each will slow down according to Eq. (18), so their information speed remains c or less. In the case of a small and a large mass, a large mass will therefore slow down very little and a small mass (such as a photon) will slow down considerably. In this case, a collision faster than c never happens even if the relative speed, initially, far exceeds c. Due to increasing information influence, the relative speed must change to become c just before the collision, in order for information speed to remain c.

Force, inertial mass and Newton's Second law of motion

For a large information source, i.e. a cluster, the information influence of a distant particle on a cluster declines with the cluster's size, per Eq. (4). Thus the rate at which the change in motion of cluster *k* happens in time is reversely proportional to the size of a cluster*:*

$$\frac{\Delta v_k}{\Delta t} = \frac{F(i_{kc}, i_{kp})}{i_k}$$

where I_{kc} and I_{kp} are the current and previous spatial information available at the location of cluster *k*, the information interaction of which is the usage of spatial information; i_k is the information capacity of cluster *k*; v_k is the speed relative to a distant particle, and $F(I_{kc},I_{kp})$ is a function of interaction that produces change in velocity as a result of the spatial information use if each particle in the cluster were isolated, i.e. not part of the cluster. We have from above:

$$F(i_{kc}, i_{kp}) = i_k \times \frac{\Delta v_k}{\Delta t}$$

When the cluster is moving relative to a distant particle, its spatial information throughput will be lower, and even though the information capacity of a cluster remains constant, in order to simplify the above equation and account for the changing spatial information throughput, we can imagine that the throughput remains constant, but the information capacity of a cluster increases to become:

$$\frac{i_k}{\sqrt{1 - \Delta i_k^{\,2} / i_k^{\,2}}} \qquad (21)$$

The change in velocity is a vector corresponding to the change in motion, so we can introduce a vector represented by $F(I_{kc},I_{kp})$. Also, since the spatial information throughput changes in time, for example with changing speed, we need to account for the changes in time of the above imagined increase of information content of a cluster. Finally we will make the duration of a time period very small, so we have:

$$\vec{F}(i_{kc}, i_{kp}) = \frac{d}{dt}\left(\frac{i_k \times \vec{v}_k}{\sqrt{1 - \Delta i_k^{\,2} / i_k^{\,2}}}\right)$$

In the corner case of a nearby large isolated information source, from Eq. (20), we have:

$$\vec{F}(i_{kc}, i_{kp}) = \frac{d}{dt}\left(\frac{i_k \times \vec{v}_k}{\sqrt{1 - {v_k}^2 / c^2}}\right) \quad (22)$$

From the similarity with Newton's second law of motion, and with its relativistic version, we say that the information content of a particle is linearly proportional to its inertial mass at rest, and in a proper system of measurements, they are identical:

$$M = i \quad (22.1)$$

From Eq. (21) we can say that inertial mass does not increase, but rather the rate at which it can change the state of motion decreases. For many purposes, the two notions are the same.

How is spatial information used to produce force

Because usage of spatial information is statistical in nature, and because the amount of spatial information from a particle declines with the square of distance, a particle must have a large redundancy in its self-information in order for its information to have the furthest range in physical space. For instance, a particle could have only two distinct facts in its self-information (let us call them facts P_1 and P_2), but its information capacity could be very large, for example, 10^{40}. Then, half of this capacity could be P_1 facts, and the other half could be P_2 facts. The information capacity of a particle only serves a purpose to project its information influence far and large; the actual number of distinct facts in the particle's self-information can be as few as one or two.

It is reasonable that the presence or absence of a particular fact in the particle's self-information determines the way other particles interact with it. Interaction between particles, being as it is a change in the state of motion, is the result of information interaction. For example, if particle p_1 has fact P_1 in its self-information, and this fact, when interacting with fact P_2, causes a change in motion, then another particle p_2 that has fact P_2 and is reasonably close to p_1, will interact with p_1 and change its motion. We consider a presence of a single interaction fact pair, such as (P_1,P_2) to lead to the change of motion. We do not assume the amount of facts in the interaction set is a measure of the change of motion, because such amount of facts would depend primarily on the information capacity of particles involved, and not on the distinct spatial information they possess. We have said the purpose of information capacity is only to extend the information influence of a particle in space, and nothing else.

A particle accelerates as a result of a given interaction fact pair, such as (P_1,P_2) alone, i.e. in general as a result of spatial information use. The actual acceleration is the result of superposition of any interaction fact pairs that a particle will act on. If a particle accelerates frequently, we can measure that as a higher acceleration, and vice versa. A particle will accelerate frequently, in our example, if there is at least one pair (P_1,P_2) in each interaction set. If there is an interaction fact pair (P_1,P_2) in every other interaction set, its acceleration will be halved. *Both previous and current* information have to possess at least one interaction fact pair, such as (P_1,P_2), in order for *the direction of movement to be apparent*.

In terms of ways of interaction, physical matter can interact with or without exchange of particles. Both methods are in some ways the same, as the spatial information at a given location comes either from remote physical matter, or from a carrier traveling from it. In other ways, they are not the same, since a carrier takes some time to reach a given location. Since spatial information declines with the square of distance, interaction without an exchange of particles would suffer from declining information influence. A moving particle can deliver spatial information content near receiving physical matter, and have a relatively high information influence. For example, particles moving close to a local speed limit can deliver spatial information as one possible way of interaction.

Newton's Third and First Laws

The result of information interaction, as it is in our example, is a function $F(I_{kc},I_{kp})$ from Eq. (22). In the case of two particles, each particle will collect spatial information from the other particle and from itself. In our example with two distinct facts, either particle will change its state of motion, if both facts P_1 and P_2 exist in their previous *and* current information, which we write as a function $r(P_1, P_2)$ that returns 0 or 1, i.e. either the change of motion will happen or it will not, where an inverted *V* sign means 'logical and', and a stylized *E* means 'exists in a set':

$$r(P_1,P_2)=(P_1\in i_c,i_p)\wedge(P_2\in i_c,i_p)\in\{0,1\}$$

i_c and i_p are the previous and current information of a particle. A function $r(P_1, P_2)$ will return the same value for both particles most of the time, assuming particles are not too far away *and their information content is of good size.*

The function $F(I_{kc},I_{kp})$ will depend on $r(P_1, P_2)$, and on some function of distance $f(R)$, which returns the number of interaction sets where $r(P_1, P_2)$ is equal to 1 in a unit of time, thus signifying how often acceleration happens. This function will likely be the inverse of the square of distance R, because the density of spatial facts declines like that, accounting for most forces over large distances that do decline with the square of distance, both in the case of direct information influence via spatial information, and by means of carrier-particles:

$$f(R)=f_1(1/R^2)$$

For two particles *m* and *n*, we can write that the force will be on both, assuming $a(P_1,P_2)$ is the unit of acceleration produced by the presence of the interaction of facts P_1 and P_2:

$$F(i_{mc}, i_{mp}) = r(P_1, P_2) \times a(P_1, P_2) \times f(R)$$

$$F(i_{nc}, i_{np}) = r(P_1, P_2) \times a(P_1, P_2) \times f(R)$$

$$F(i_{mc}, i_{mp}) = F(i_{nc}, i_{np})$$

This means that *the force between the two particles must be statistically mutual and equal.* This is the expression of the Newton's third law of motion. The first Newton's law follows when $r(P_1, P_2)=0$, i.e. when the two interacting facts are not present, in which case there is no force, and there is no change in motion.

Statistical nature of physical interaction and examples of divergence

Whether a particular interaction fact pair, such as in our example (P_1,P_2), will be found in the interaction set, is a statistical happenstance, because spatial information is a discrete scalar physical field. There is a chance, albeit small, that an electron can fly by a nearby electron without changing its state of motion, because it may not have collected any spatial information from the other electron. At the same time, the other electron may have changed its state of motion, apparently violating the law of impulse preservation. Because we assume that information capacity of particles is large, this would be a very rare event. Because of this, we can say the interaction between particles will appear to follow certain laws, but such laws cannot be strict, especially on a small scale or at small distances, or at all times.

As an example of divergence, consider when the distance *R* between particles is very small. In this case, the density of spatial information is very high and the distance between particles is comparable to the particle's size. Thus, the decline in the density of spatial information over the body of a particle will be lesser than the square of distance, and the amount of spatial information collected higher, and so, such interactions may be *stronger* than those following the square distance law. As another example, a certain fact, for instance P_3, may be present in very small quantities in a particle's information content. For instance, if a particle has 10^{50} facts in its information content, and has three distinct facts, such as P_1, P_2 and P_3, then the distribution of such facts can be any, and in general unequal. For instance, facts P_1 and P_2 can each account for approximately $10^{50}/2$ of the information capacity, and there may be only 10^{10} of P_3 facts. In this case, any force requiring P_3 will be of *extremely short range*, because at any appreciable distance, fact P_3 will be statistically far outnumbered by facts P_1 and P_2. What we have described in this paragraph is sufficient to explain the existence of *nuclear forces*, and in general, forces that are short range and powerful.

The effects of change of information throughput on physical interaction

We have said that, if there is a change in the throughput of spatial information usage, then the moments in time in which a particle accelerates become less frequent, and the acceleration of a particle declines. By definition, this means that a particle changes its behavior. It will no longer interact the same way. It means the nature of physical interaction will change in a non-trivial way. For example, a stream of electrons may change density in some spots when in motion relative to a large mass.

When Eq. (20) holds, and in a very simple case of a rigid rod moving relative to a large mass, the distance between the repelling constituents, such as atoms and molecules, will evolve differently in time, because the outward acceleration that keeps them apart will become less frequent and, at the same time, particles will cross longer distances without changing the state of motion.

In general, changes in the way particles accelerate over time cause functional changes in physical interactions and structural changes in objects. This applies whenever there is additional information, i.e. both due to motion and the presence of other mass.

Gravitational time dilation

Particle *n* is at some distance from particle *m*. We will consider the randomizing of spatial information of *m*. During an information cycle, randomizing of *m* changes spatial information at the location of *n*. This new information is collected by *n* and used - this is R-additional information. To calculate the amount of this additional spatial information, we will consider an indirect method. We will look as to how much R-additional information changes as particle *n* moves away from *m* by just a little bit, and then by summing it up, find the equivalent speed at which particle *n* would have to move away from *m* in order for the same change to happen due to M-additional information alone. At the end, we will use this equivalent speed in equations we already have.

The longer it takes for *n* to move away radially from *m* by *dR*, the more of *m*'s information will add to *n*'s data due to randomization, hence the change of R-additional information $d(\Delta i_n)$ is proportional to a small time interval *dt*. The more of *m*'s spatial information is present at the location of *n*, the greater the amount of newly randomized content is, and the greater will the change of R-additional information be, thus the change is proportional to the density i_m/R^2. The higher the information influence of *m* at *n* is, the more of the above spatial information change will be actually collected by particle *n*. So we write:

$$d(\Delta i_n) = -w \times (i_m / R^2) \times i_n \times f_{mn} \times dt \quad (23)$$

where $d(\Delta i_n)$ is the change in R-additional information of *n* due to reloading effect of *m*; *w* is a term of proportion that effectively describes how often the spatial information of *m* is randomized in a unit of time; i_m is the self-information of *m*; *R* is the distance between *m* and *n*; the density of spatial information of *m* at location surface of *n* is i_m/R^2; f_{mn} is the information influence of *m* at *n*; i_n is the self-information of *n*, and $i_n \times f_{mn}$ is the portion of *n*'s current spatial information that comes from *m*; *dt* is a small time interval it takes to change distance by *dR*.

There is no change due to motion effect because the speed is uniform and f_{mn} is practically constant.

Now we will find the equivalent speed for the same change, *due to M-additional information alone*.

Let n move away from m by a small distance dR with radial speed increasing by dv_R. Here we ignore the randomization effect and consider only the motion effect. There will be an increase of M-information due to the motion effect. The change in M-additional information due to the change of speed dv_R is, from Eq. (5):

$$d(\Delta i_n) = s \times i_n \times dv_R \times f_{mn} \quad (24)$$

By equating Eq. (23) and Eq. (24), in order to find the equivalent speed that produces M-additional information equal to R-additional information, we can substitute:

$$\Gamma = w / s \quad (25)$$

And further we have:

$$dv_R = -\Gamma \times (i_m / R^2) \times dt$$

Multiplying both sides by v_R, and with $dR = v_R \times dt$, we have (knowing that at distance of infinity the randomization effect vanishes and so the speed is zero):

$$\int_v^0 v_R \times dv_R = -\int_R^\infty \Gamma \times (i_m / R^2) \times dR$$

The solution is:

$$v_R{}^2 = 2 \times \Gamma \times i_m / R$$

v_R is the *randomization equivalent speed*. From the limiting case of Eq. (20):

$$dt_1 = dt_2 \Big/ \sqrt{1 - 2 \times \Gamma \times i_m \;/\; R \times c^2} \quad (26)$$

This is the slowdown of physical time due to the randomization effect of *m*. All physical clocks tick slower, when closer to other physical matter. Or, more precisely, the rate at which acceleration happens is lower near other physical matter, than it is farther from it.

Gravitational mass and Newton's law of gravitation

We assume that information resources are finite. Here we examine the consequence of *acceleration resources* being finite as well. The physical effect of spatial information use is acceleration, and we will assume that resources a particle uses to accelerate are limited. We will accept that physical matter can move to minimize the use of both information and acceleration resources, the sum of which are *physical resources*, signifying total resources needed to exhibit physical effects.

Postulate VI: *Physical resources of matter are finite, and matter will move towards location of their permanent lower usage.*

We have seen that physical matter changes motion slower when closer to other physical matter. The acceleration of a particle is less frequent with lower spatial information throughput. A particle will, thus, change motion to move towards other particles in order to achieve permanent lower usage of physical resources, i.e. it will accelerate towards other particles. This is *resource reduction acceleration*, or just resource acceleration for short.

Since the shortest route toward another particle is directly towards it, we will examine radial movement only. The resource acceleration thus must be directly towards another particle. If dv_R is the change of radial speed in resource acceleration, then we can establish the acceleration cost *C* as the pertinent change in spatial information throughput:

$$dC = \frac{\partial T}{\partial v_R} \times dv_R$$

The gain of acceleration resources *Y* happens because the distance *dR* between particles has changed:

$$dY = \frac{\partial T}{\partial R} \times dR$$

The sum *C+Y* represents the total acceleration expenditure of such movement (the cost *C* is negative and the gain *Y* is positive). We will find the conditions under which the total acceleration expenditure is minimal:

$$\frac{d}{dt}(C+Y)=0$$

or:

$$\frac{\partial T}{\partial v_R}\frac{dv_R}{dt}+\frac{\partial T}{\partial R}\frac{dR}{dt}=0$$

and we can express this via additional information Δi, consisting of M- and R-additional information:

$$\frac{\partial T}{\partial(\Delta i)}\times\frac{d(\Delta i)}{dv_R}\times\frac{dv_R}{dt}+\frac{\partial T}{\partial(\Delta i)}\times\frac{d(\Delta i)}{dR}\times\frac{dR}{dt}=0$$

The derivative of additional information with change in speed affects only M-additional information, while the derivative of additional information with change of distance affects only R-additional information, in a small area where information influence can be considered constant. For the change in R-additional information we will use Eq. (23), and for the change of M-additional information we will use Eq. (5). If we name the two particles *n* and *m*, with *n* moving towards *m*, we have from the previous equation:

$$s\times i_n\times f_{mn}\times\frac{dv_R}{dt}$$
$$+w\times(i_m/R^2)\times i_n\times f_{mn}\times\frac{dt}{dR}\times\frac{dR}{dt}$$
$$=0$$

and with the same constant as in Eq. (25):

$$\frac{dv_R}{dt} = -\frac{\Gamma \times i_m}{R^2}$$

This is the derivation of Newtonian gravity and so it must be:

$$\Gamma = G$$

where *G* is the gravitational constant. Resource acceleration is the same as gravitational acceleration. The Eq. (26) can now be written as, by keeping in mind that inertial rest mass *M* is the same as particle's information content, from Eq. (22.1):

$$dt_1 = dt_2 \Big/ \sqrt{1 - 2 \times G \times M \;/\; R \times c^2}$$

A look at works by other authors

The role of information in physics has been considered before. It was suggested in Zuse’s[3] work that the Universe may be a huge cellular automaton, or rather a classic Turing machine as suggested elsewhere. These and similar theories attempt to view the Universe as a computer that can be simulated, i.e. as a hyper-computation. The number of bits needed to do so would be huge - some estimates put it to 10^{90} bits. We show that no single computer, regardless of its processing power or number of bits, can simulate the Universe. The reason for this is that physical matter has finite information resources, i.e. in general there are less resources than there is spatial information available to use. As such, the choice of which spatial information to use, and which not to use, is random at the foundational level. No computer can predict these choices. The same argument holds with regards to the work of Jurgen Schmidhuber (pan-computationalism, or the computational universe theory). These theories, regardless of their appeal (the popular one being able to compute all possible histories for all types of physical laws) differ strongly in that they do not account for the statistical nature of spatial information use.

John Archibald Wheeler expressed a view that information may be at the core of physics, where it may play a role similar to that in a computer. This is a well-known *it from bit*[4] paradigm. The direction it took, however, differs greatly, delving more into the realm of epistemology and consciousness, and less into the realm of verifiable aspects of fundamental physics, or more importantly, the new predictions in that realm.

A recent work by David Deutsch (Qubit Field Theory[5]) touches on the possibility of physical space containing information. However, Qubit Field Theory does not consider information to be truly foundational. Rather, information is presented within the framework of relativistic time-space.

Shannon's information theory[6] is not discussed because it has no direct relevance. Modern information theory examines observable information, ultimately resulting from the interaction of physical particles, and not the spatial information *used by* the physical particles. Spatial information is not observable, but rather only the physical effects of its use are. Because Shannon's information theory rests on the laws of physics which we can deduce from our assumptions, the two are in agreement. It would not be appropriate to directly compare the two theories.

Conclusions

We have developed herein a theory of physical matter possessing and using finite information content, with only the nominal assumptions with regards to Relativity. To do so, we have removed any dependency on external observers in formulating the laws of Nature, and rely solely on the use of information in a small local frame of reference, i.e. nominal relativity. Somewhat surprisingly, effects known as relativistic are found to be in accordance with this assumption, without the postulates and principles of full-blown Relativity, raising the question of whether it is needed at all.

The principal reason for the abandonment of the concept of light-matter medium in the early 1900's (so called “luminiferous aether”) was its incongruity with the experiments such as the de Sitter and Michelson-Morley, giving rise to the expansion of the concept of Relativity. We have shown these experiments to be easily predicted via premise of information content of physical matter and the reasonable assumptions of its use. Because those premises neither require nor deny the presence of any kind of medium with the help of which both light and matter waves propagate, either as a propagation or as a guiding-pilot medium, we can now consider the possibility that the waves of Quantum physics are real, and not waves of probability. Such a medium would be made of physical matter, which is subject to the same laws we heretofore derived, the prominent one being that the maximum speed of its motion depends on the location, and near a large information source like Earth, it is always *c* relative to it.

In addition to allowing quantum waves to be real, the very premise of the finite and discrete nature of information yields some of the quantification as it is postulated in Quantum physics. The use of spatial information is shown to be probabilistic in its nature, due to limited information resources of physical matter, giving way to its indeterministic stature. What is important from the core perspective of a theory is that the phenomena we know as “quantum” and “relativistic” are both shown to be singularly informational, without any separation of principles between the quantum and relativistic.

In the course of developing the theory, we have introduced the notion of information speed, which does not depend on any relative speeds, or any choice of frames of reference. It signifies the throughput of information in physical matter. We have also introduced the concept of a constraint group, which is the set of objects that influence any given matter the most. It is the constraint group that determines the maximum local speed of any given matter, relative to any other object.

We have deduced that the information speed has a maximum value which we found equal to *c*. The actual maximum speed varies with location and differs relative to the mass that influences the object in motion the most, i.e. varies with the current constraint group. Such maximum speed can exceed *c* or be lower than *c* relative to various observers, and such speed limit is different from the speed of light in general. Speed of light is simply the maximum speed of a very small particle nearby a very large isolated mass.

In other words, all objects moving with maximum speed in any given location have the same information speed *c*, but their actual speed relative to other object varies. Somewhat unfortunately, the two speeds, information and spatial, are practically one and the same near a large isolated mass like Earth, and the difference is not apparent in many other cases. Information speed involves not just the two objects moving relative to one another, but rather it may involve all objects in existence, and it only reduces to relative speed in the aforementioned corner cases. By accounting properly for the difference between information and spatial relative speed, we have seen that de Sitter effect and Michelson-Morley experiment are easily explained without Relativity.

Recent observations of the lack of time dilation in quasars[1] are in agreement with the results obtained here. Time dilation depends on the constraint group of a given mass, making it non-trivial to express the exact rate of physical time in all but the simplest cases, such as those found near massive isolated objects like Earth. Very large masses are more likely to experience negligent time dilation and to be free to move with speeds that exceed *c* relative to us, as it has been observed in "superluminal motion of galaxies"[2], while at the same time, their light can still reach us. This is because the speed of a photon changes the way its constraint group changes, i.e. the way its disposition to other masses changes, and relative to us on Earth, can be higher or lower than *c*.

A preponderant body of experimental results, from over a hundred years past, including known relativistic experiments, is apparently in accordance with our results, because our results reduce to that of Relativity. We have focused on a different initial approach to the theory itself, which in certain corner cases, having never been a subject of direct observation, diverge from known theories, thus providing good basis for new experiments. Conceptually, the approach taken here is before the first principles, and relies only on the premise of usage of information content by physical matter and the postulates that are thought valid on their face, i.e. axiomatic, and *not* on the experimental facts taken as laws of Nature. The reasoning process we employ could be said to *objectify* the topic of time dilation and associated phenomena, as we arrive to it by providing the *internal* view of time dilation as well as the *underlying structure*, and not as it is by definition in Relativity, by the invocation of the equality of points of view of external observers.

We have shown that the infinitesimally small time *dt* in physical equations cannot be infinitesimal, but rather is a minimum finite period of time in which a physical particle does not change its state of motion. In the context of time dilation, we find that kinematic time dilation depends on the mass of the many relevant objects, and their distances, and not just the relative speed of the two frames of reference, and with such effect being in addition to gravitational time dilation. Time dilation effect in general is relative to a flow of time of a smallest possible isolated mass infinitely far away, as a baseline. Simple symmetrical relations that exist in Relativity between observers no longer apply, even if the framework from which such symmetrical equations arise could be compared directly with our approach of nominal relativity, which it cannot. For example, when a high-speed object approaches Earth, the clock onboard this object would slow down, while the clock on Earth would slow down negligibly. Such a statement is presented with the aforementioned baseline for measuring changes in the ticking of clocks, and not in the context of Relativity, as we cannot directly "crossover" most statements this way between the two theories, due to a fundamental difference in the initial approach. Aside from the notion of nominal relativity holding a faint resemblance to the principles of Relativity, there is virtually nothing to directly connect the two, save for predicting the same experimental results. Finally, we conclude that the equations of Relativity hold fully true only in the case of an isolated large mass. In other words, the equations such as for time dilation and mass increase, are reduced to the ones of Relativity only in cases of such astronomical isolation, while in general, those equations are different.

On the note of difference, it is important to state that there is *no need* to empower external observers with the effective arbitration of natural laws. They *certainly can* examine such laws, but because such requirement is patently absent, the issue of simultaneity now has no point.

In Relativity, deductions follow from the premise that certain phenomena deemed fundamental, appear the same way to all frames of reference, i.e. to both local and external frames with respect to such phenomena, and from such a premise we get kinematic and gravitational time dilation. For us, both the premises and the deductions of Relativity are the consequences of the limited information resources of physical matter, and in the case of the speed of light, the aforementioned constancy does not always hold either. Factors v^2/c^2 and $2GM/Rc^2$ are generalized with the factor $\Delta i^2/i^2$, which has a singular physical interpretation as the loss of spatial information a particle uses, due to its finite resources. We find that the "seat" of relativistic effects doesn't have to be Relativity, i.e. it *need not* be about expecting physical phenomena to comply with the observer's view from the outside therein. We find that the "seat" of such effects is in the internal workings of matter, and moreover, workings that are independent on any particular physical model and independent on any external frame of reference. Rather, the inner workings we speak of, represent *the universal tenet of logic that any physical action must come from applied information content*, in whatever shape or form.

Gravity is shown to be a consequence of a permanent gradient of the spatial information throughput in a direction in space. We also showed that relative motion creates a change in the spatial information throughput of physical matter as well, and as such, it can influence the gradient arising naturally from the presence of mass.

Overall, even with the predictions provided by the theory, perhaps the most curious and interesting aspect is formulating the precise results of Relativity, both Special and General, as corner cases, without using any of its postulates or the first principles of physics, and as such, without knowing that light, mass and gravity exist *a priori*, all the while allowing for quantum effects within the very same framework.

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