God play dice?

by mel viso.

1 Introduction

I remember when I was a small child, the day I discovered the dictionaries that were in my parent's house and how to use them, I was excited: In only two books, so many definitions about what things are ... some words I knew, some others that were new for me and in this way I remember spending weeks and months looking for new words and reading their meanings. The way to define the words, trying to use expressions as brief and precise as possible, also caught my attention. It was for me a infantile game trying to explain things this way.

My first mistake, like the one of almost all children when trying to define something for the first time, was to say that a food was something that it fed. And my mother corrected to me opportunely explaining that the defined thing cannot be included in the definition. So when a food happened to be a substance that provided a kind of material or energy resources needed for a living being, I realized how difficult it was to define some things to avoid considering batteries or bricks as food.

It was not until some years later, while I was studying physics, that I went back to the problem of definitions.

The Physics as a science that studies the behavior of matter, its properties and interactions, uses (among others) the meter and the second as units (fundamental units). These units serve to decorate the quantities and allow, for example, to avoid confusing 15 kilograms of potatoes with 15 kilometers of road.

The units of measurement are a good invention. But like all inventions, they are not perfect. What has evident advantages also originates problems. For this reason, the science evolves, adopting different points of view, sometimes even knowing that they are not true, because they simplify some problems and give good solutions. [1]

[1] In analytical mechanics, the use of generalized forces greatly simplify the description of the movement of complex mechanisms, but they are not real forces. The reader will surely have heard of the "centrifugal force" that doesn't really exist, since the real force is the "centripetal force".

In the case of units of measurement, and in particular in talking about space and time, the fundamental units do not provide any other information related to the physical property they express, apart from the classification of the quantity or magnitude to which they label: 1 meter, 2 seconds, 27 kilograms... This classification of magnitudes allows physicists to indicate the valid relationships that exist between them.

Although everyone can differentiate between one meter and one kilogram, the difference between units is based on our knowledge of its applicability, its use, our experience and intuition. But the intuitions can be wrong, as when we were children and could believe that the air didn't weigh. Some of these erroneous intuitions of children are no different from those of adults at no more than the moment of the history which provides a certain knowledge to form a consensus opinion in the interpretation of the reality.

The fundamental units are somewhat similar to the Mathematics axioms: They are not defined. They are considered as true and are used. It is said that these fundamental units have an "operational definition" that consists as approximately in saying how they are used, but even if the adjective "operational" is added, that could not be considered as a definition in the strict sense. A characterization of the mode of use or operation of something does not define (does not explain **what** it is) something. It can give us information about its usefulness or its meaning, just as the use cases of a mathematical axiom give us an idea of its importance or utility.

In this work we present a way to deal with the "fundamental" units of space and time as derived values from a model that, despite to be very basic, is much better than a "operational definition", since the first is improvable and the second is a dogma of faith. As a defense of the presented model, we will show how this model explains special relativity (not as an experimental fact, but as a consequence of the proposed model) and the constancy of the speed of light, in addition to opening the door to a new path for research on the nature of space and time.

2 The distance for a child

Sometimes the progress of the science is related more to changes in the way of understanding physical phenomena than to new discoveries. Changing the way we see the things opens new perspectives, new research paths.

Applying this to the space, looking for a new way of defining distance, it is required for a new definition to be as simple as possible and to coincide with our experience in order to be accepted and be useful.

The problem of looking for a new way to define a property of the space is that this is an intuitive concept and rooted in our everyday use, to the point that we move in it and assume its properties (metric, isotropy, ...) as something natural and, for this very reason, it resists to have a deeper analysis.

An interesting starting point is to return to our origins, to our first perceptions of the space. When we were aware of the existence of space? What kind of facts created in us the need for this perception?

It's possible that the first experience about space relates to properties as simple as near and far. "Close" means something with which a toddler or baby may collide (interact) and "away" means something that's outside the "danger zone".

A collision or impact probability is actually an interaction probability. This interaction that may be mechanical, electromagnetic, etc, is the only verifiable physical fact that gives us real information: The light that comes into our eyes gives us information about the environment that surrounds us because the photons interact with our retina. When we use a ruler to measure a distance, our vision and touch informs us if the ruler is in the correct position and the measured value. The physical interaction is the fundamental fact in which information is exchanged, that allows the construction of an interpretation of the physical world.

Ultimately, the only "real" and verifiable experience is this interaction, and it is on the basis of it that we built all other concordant interpretations of our reality.

To date we have build our interpretation of the physical world without regarding the physical interaction as a real basis for our physical world interpretation, in a deeper sense, and we have built our laws and theories on the basis of our agreement with our experience, without take in consideration the mechanism we used for gathering the information. Maybe the time has come to make our way back and use all this information we have obtained to rebuilt our interpretation of physical reality from a more precise point of view.

The nature of the interaction between physical objects (electromagnetic, mechanical, ...) is different to the metric properties of the interacting bodies. But the principle of uncertainty and thermodynamics teach us that all bodies are always in motion, at least on a microscopic scale, while relativity limits the speed at which any object can move, so the statistical probability of interaction is related to the distance between the physical objects that interact.[2]

In contrast with what happens in Mathematics, in Physics you can't talk about probability without take into account the time. This is because as in Mathematics we can describe theoretical (populational) statistics, Physics works with real (sampled) statistics that require that the things that we need to count happens.

[2]Except for the quantum entanglement, which is a special type of interaction and does not allow the transport of information

Due to that reason, we can't talk about a distance based on a probability, without take in account the existence of the time.

2.1 About the time

What is Time? The greek thinker Democritus (460-370 BC) developed the atom theory that was enunciated by his mentor Leucippus, following logical reasoning. The existence of the atom was inferred by simple observation of reality. Arguments such as the existence of regularity in the size of things or the existence of constant proportions between physical objects requires that it exists a singular dimension that works as a reference or basis for building stable scale factors. Speaking about a singular (microscopic) scale or speaking about a size in which the properties of matter are not the same as in our (macroscopic) scale, is the same as talking about the existence of atoms, electrons, or anyever elements that builds the matter that we know and such that below its scale, the properties become different.

To put it another way, the existence of atoms answers the question of why the relative sizes of things are constant: The atomic scale works as a reference for all constructions of matter.[3]

The existence of atoms not only explains this constancy of proportions between things, but is necessary for that. We can call them atoms, bosons, leptons or whatever we want, but the existence of a singular scale is equivalent to the existence of a discrete scale (formed by distinguishable elements).

If we apply the same reasoning to the time, the constancy of the time intervals of similar processes (why do we age at the same speed? Why do two clocks go at the same speed?), leads us to suspect that the temporal scale has to be subjected to a system of reference where things are not equal and, emulating Democritus, that the time should not be infinitely divisible.

Describing time as a physical phenomenon is a delicate matter, because it is easy to incur in unprovable (non-falsifiable) proposals [4] These kinds of proposals bring us nothing beyond a bit of mental fun. An example of theories of this kind might be:

The time in the entire universe stops daily while the machinist, who handles it from the outside, is eating.

[3] To be fair, the subject does not end here, since the constancy of the relative size of atoms becomes the next problem, but for the moment we are only interested in introducing the necessity of the existence of reference scales.

[4] Scientific theories must be "falsifiable", which means that there must be a way to determine if that theory is true or false.

The stop of the time in this example, would mean that there could be no physical perception of what such a thing happens. It would be assumed that, when the universe were started up again, it would do it just at the same point it had left and therefore, from the point of view of the time within the universe, the stop would not be detectable.[5]

The previous example tells us that there is no point in talking about a "time of the time". All the temporal experience that we can have is relative. So immediately the question arises (in colloquial terms): Does the time pass at the same speed in two different places in the universe[6]? The most logical answer, from the point of view of possible cases, is no, as the time lasting exactly the same would be a particular case.

The theory of relativity even further complicates the answer to this question, because the intervals of time and space are not separately comparable in the general case. Even so, Physics tells us that there are special systems, called inertial systems, in which, apparently, the time is comparable, and clocks mark the same hour, so we rephrase the question: Can two clocks belonging to the same inertial system indicate, simultaneously, identical time measures?

Daily experience tells us that the response is yes. But since all our observations are subject to errors, the more general answer is still no: Two clocks could incur in undetectable differences and give a false sense of sinchronization.

To illustrate this hypothesis and make things somewhat clearer, we could suppose that the time be composed by discrete intervals and that our seconds hold, on average, 10^{20} of these intervals.

If these time intervals follows a statistical distribution similar to the frequency of cars passing through a street (Poisson distribution of rare events), the mean error between one second and another second would be 10^{10} of these intervals or, what is the same, 10^{-10} seconds. To have a mean error of 1 second between two clocks, we should allow at least 10^{40} of these intervals (3 trillion of years).

At the time of writing, the world's most accurate clock, based on strontium, seems to have a precision of 1 second in 15 million years, but even if a more precise clock were created, it wouldn't solve the problem, as the time intervals could be even smaller. Only a perfect clock would solve this doubt, and quantum physics tells us that at the end we could find probabilities and, if we know

[5]Only is an example to illustrate the concept of falsifiability, the proposition of that time could be stopped in this way in the universe would imply that it wouldn't be a simultaneous detention for all observers, taking into account the relativity theory, and we would have to enter into a deeper discussion between simultaneity and perception.

[6]To be precise, that the temporal intervals have simultaneous boundaries.

exactly the position of a minute hand in an instant, the error in its speed would be infinite. This prevents us from measure time intervals as small as we want.

The probability of physical interaction is a probability conditioned by the existence of a time interval in which this interaction can take place or not. But since the probability of existence of the time is not measurable from within the time itself, the only perception we can have regarding the statistical behavior of the time is relative to the behavior of different clocks.

2.2 The distance from the interaction probability density

Experience tells us that we live in a space that has three degrees of freedom, so given two bodies A and A' that may interact at a given instant, these objects must have positions that can be parameterized by three coordinates.

Let be μ_x, μ_y and mu_z the coordinates of body A and μ'_x, μ'_y and μ'_z those of the body A'. We do not yet suppose that these coordinates express a distance between bodies, but his concordance with the probabilities distribution of interaction between these bodies.

If we assume that this distribution comes from an infinity of unknown and independent factors, the central limit theorem indicates that this distribution should be a Gaussian expressed in terms of the differences between random variables that indexes the bodies, so that would have a formula of the type [7]

$$\psi(p) = \frac{1}{(2\pi)^{\frac{3}{2}}\sigma_x\sigma_y\sigma_z} e^{-(\frac{(\mu_x-\mu'_x)^2}{2{\sigma_x}^2}+\frac{(\mu_y-\mu'_y)^2}{2{\sigma_y}^2}+\frac{(\mu_z-\mu'_z)^2}{2{\sigma_z}^2})} \tag{1}$$

In this formula, the parameters σ_x^2, σ_y^2 and σ_z^2 represent values related to the error margin called variances.[8]

This error margin depends on the chosen scale. In other hand, since the space seems to have the same properties in all directions (a rule does not stretch or shrink when rotated), this means that we have chosen a natural scale on which the variances of each parameter have the same magnitude, so if we call it σ_s (spatial variance) to this common magnitude, the formula of the Gaussian density distribution may be expressed as:

$$\psi(p) = \frac{1}{(2\pi)^{\frac{3}{2}}{\sigma_s}^3} e^{-\frac{(\mu_x-\mu'_x)^2+(\mu_y-\mu'_y)^2+(\mu_z-\mu'_z)^2}{2{\sigma_s}^2}} \tag{2}$$

[7] An extended interpretation of this expression is that each body has to interact at any moment with other physical elements of the universe, or simply would not exist. Such interaction may be mechanical, electromagnetic, etc., but the total distribution must be normalized if interacting and existing means the same thing.

[8] The square root of a variance is called the standard deviation. In a one dimensional gaussian distribution, the interval centered on the mean value with radius 2*σ contains about the 95% of probability of occurrence

What information gives us that probability of interaction? Based on Shannon's information theory, the density of information provided by that density distribution (in nits) is:

$$I = -ln(\psi(p)) = \frac{(\mu_x - \mu'_x)^2 + (\mu_y - \mu'_y)^2 + (\mu_z - \mu'_z)^2}{2{\sigma_s}^2} + \frac{3}{2} * ln(2\pi) + 3 * ln(\sigma_s) \tag{3}$$

Rewriting the above formula for separating the scale factor:

$$I * 2\sigma_s^2 = (\mu_x - \mu'_x)^2 + (\mu_y - \mu'_y)^2 + (\mu_z - \mu'_z)^2 + 3\sigma_s^2 * ln(2\pi) + 6\sigma_s^2 * ln(\sigma_s) \tag{4}$$

The spatial variance, in the case it exists, must be an extremely small value, so that very roughly on the macroscopic[9] scale we can write an expression for the distance between bodies by the expression:

$$d(A, A') = \sqrt{2\sigma_s^2 * I} \approx \sqrt{(\mu_x - \mu'_x)^2 + (\mu_y - \mu'_y)^2 + (\mu_z - \mu'_z)^2} \tag{5}$$

This is the proposed expression for the distance between two bodies:

$$d(A, A') = \sqrt{2\sigma_s^2 * I} \tag{6}$$

[9] It may be interesting to investigate the implications of the small terms $3\sigma_s^2 * ln(2\pi) + 6\sigma_s^2 * ln(\sigma_s)$ in quantum physics.

3 Uniform rectilinear motion and Lorentz equations

Lest suppose that between two instants of time observed for the same phenomenon, at two points in an inertial system, there is also a Gaussian distribution of the form

$$\psi(t) = \frac{1}{\sqrt{2\pi}\sigma_t} e^{-\frac{(t-t')^2}{2{\sigma_t}^2}} \tag{7}$$

The parameter σ_t^2 is the time variance.

Now let us suppose that a body moves within an inertial system with the classical equation of uniform rectilinear motion, but expressed in the distribution variables (unobservable [10]).

$$\mu'_x = \mu_x + v * t \tag{8}$$

For calculating the observed position of the body, we have to use expression (5). If we assume that $\mu'_y = \mu_y$ and $\mu'_z = \mu_z$, the value of the information expression is:

$$I = -ln(\psi(p)) = \frac{(\mu_x - \mu'_x)^2}{2{\sigma'_s}^2} + \frac{3}{2} * ln(2\pi) + 3 * ln(\sigma_s) \tag{9}$$

In this expression we write σ'_s instead of σ_s because the variance is modified by the motion. The expression of the variance of the linear combination of two distribution variables allows us to write

$$\sigma'^2_s = (\frac{\partial\, \mu'_x}{\partial\, \mu_x})^2\, {\sigma_s}^2 + (\frac{\partial\, \mu'_x}{\partial\, t})^2\, {\sigma_t}^2 = \sigma_s^2 + v^2 * \sigma_t^2 \tag{10}$$

We Introduce the constant c = $\frac{\sigma_s}{\sigma_t}$. Applying (5) the expression of the distance to which the body lies takes the form

$$d(\mu'_x, \mu_x) = \sqrt{2\sigma_s * I} \approx \frac{v * t}{\sqrt{1 + \frac{v^2}{c^2}}} \tag{11}$$

[10] For simplicity, distribution variables will be observable in their own inertial system, but we don't denote as such (t = [t] x = [x]) and reserve the notation of observables [] for the values between inertial systems

The first consequence of this equation is that from this definition of distance, the velocity v is not an observable. The observable velocity [v] is done by

$$[v] = \frac{v}{\sqrt{1 + \frac{v^2}{c^2}}} \tag{12}$$

The absolute value of [v] will always be less than c, and applying the rule of L'Hôpital

$$\lim_{|v| \to \infty} \mid [v] \mid = c \tag{13}$$

The quantity c (velocity of light) may be expressed as a quotient between the spatial and temporal variances and will be the upper bound of the magnitude of any observable velocity.

The apparently occupied position by the moving body from the coordinate point μ_x is expressed now as

$$[\mu'_x] = \mu_x + [v] * t \tag{14}$$

3.1 The Lorentz transform equations

Between the observable velocity and the real velocity we can write the transformations

$$v = \frac{[v]}{\sqrt{1 - \frac{[v]^2}{c^2}}} \tag{15}$$

and

$$\sqrt{1 - \frac{[v]^2}{c^2}} * \sqrt{1 + \frac{v^2}{c^2}} = 1 \tag{16}$$

The classical Galilean transformation between the coordinates of two inertial systems in relative motion is given by the expression

$$x' = x - vt \tag{17}$$

Where the quantities on the left are measured in one reference system and the quantities on the right in the other one.

Assuming that this transformation were true, in observable terms and taking into account the modification of spatial variance (10) we find

$$[x - v * t] = \frac{x - v * t}{\sqrt{1 + \frac{v^2}{c^2}}} = \frac{x'}{\sqrt{1 + \frac{v^2}{c^2}}} \tag{18}$$

applying (16)

$$x' = \frac{[x - v * t]}{\sqrt{1 - \frac{[v]^2}{c^2}}} \tag{19}$$

In this expression, we have to take into account that $[x - v * t] \neq x - [v] * t$. The time t is the time in the observer system, not the observed system time, so the correct expression is

$$[x - v * t] = x - [v] * [t] \tag{20}$$

then (19) may be rewritted as

$$x' = \frac{x - [v] * [t]}{\sqrt{1 - \frac{[v]^2}{c^2}}} \tag{21}$$

On the other hand, from the expression (18) we can write

$$[x - v * t] = \frac{x}{\sqrt{1 + \frac{v^2}{c^2}}} - [v] * t = x * \sqrt{1 - \frac{[v]^2}{c^2}} - [v] * t \tag{22}$$

Combining equations (20) and (22) it provides an expression for the real time

$$t = [t] + x * (\frac{1}{v} - \frac{1}{[v]}) \tag{23}$$

If the real time exists, exchanging observer and observed, we should be able to write (taking into account the change of sign of the speed):

$$t = [t'] - x' * (\frac{1}{v} - \frac{1}{[v]}) \tag{24}$$

Equating the expressions (23), (24):

$$[t'] = [t] + (x + x') * (\frac{1}{v} - \frac{1}{[v]}) \tag{25}$$

Finally, taking into account (21), we can write the equations:

$$x' = \frac{x - [v] * [t]}{\sqrt{1 - \frac{[v]^2}{c^2}}} \tag{26}$$

$$[t'] = \frac{[t] - x * \frac{[v]}{c^2}}{\sqrt{1 - \frac{[v]^2}{c^2}}} \tag{27}$$

These are the well-known Lorentz equations for the transformation of special relativity.

To conclude, if this theory were correct, the Lorentz equations could be written in a little more general form, bearing in mind that the distributed variables are observable in their own inertial system [11]:

$$[x'] = \frac{[x] - [v] * [t]}{\sqrt{1 - \frac{[v]^2}{c^2}}} \tag{28}$$

$$[t'] = \frac{[t] - [x] * \frac{[v]}{c^2}}{\sqrt{1 - \frac{[v]^2}{c^2}}} \tag{29}$$

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[11] We have neglected that in order to simplify expressions at the expense of doing them a little more subtle.