Information in a discrete space-time

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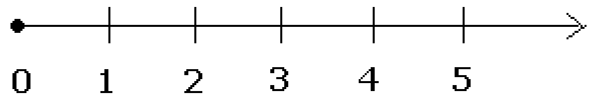
In this article analyzes the properties of information in discrete structure of space-time. In this model, each cell structure has its 1 bit of information that is stored, regardless of the state of the whole system. However, in addition to its own 1 bit each cell is stored foreign information about other cells. This way you can ensure data transmission throughout the discrete structure of space-time.

Information in the modern world is becoming an important role in all spheres of human activity. Recent work in the field of physics, information theory, biology, sociology and others confirm the relationship between matter and information at different levels of reality.
In this short note, I propose to show how easy it is to obtain quantitative information in discrete structure of space-time.

For the beginning let us consider the simplest numerical axis, which shows the numbering of natural numbers:



For this number axis will choose the interval of 1 bit of information:

$$\lambda_i = 1\ bit$$

$$i = 1,2,3,4,5, \ldots, N$$

Let every single interval of the real axis is 1 bit of information:

$$\lambda_i = \frac{d_{0(i+1)} - d_{0i}}{d_{01}} = 1\ bit$$

$d_{01} = 1$ - single interval of the real axis

This number line number information contained in the interval of numbers from 0 to N:

$$I = \sum_{i=1}^{N} \lambda_i = \sum_{i=1}^{N} \frac{d_{0(i+1)} - d_{0i}}{d_{01}} = N, (bit)$$

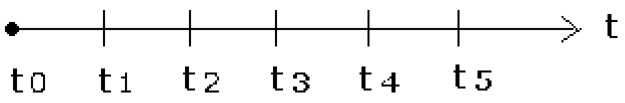
Thus numerical axis, divided into single interval of 1 bit contains a range of numbers from 0 to N information, equal to the latter.

Now let us consider the physical models numerical scales. In this case, the physical quantities of matter is not suitable, because they do not contain quantitative information, but can determine the level of relations.

On the other hand there is a certain physical object, not tied to specific material process, this is a temporary awn.

Moreover, we can show that at the time axis will be laid structural quantitative information. As in the previous example, this operation can be done if the axis of time discrete, that is, to imagine how equal segments quanta of time.

To do this, divide the time axis into equal intervals:



$$\Delta t_p = t_i - t_{(i-1)}$$ - quantum time,

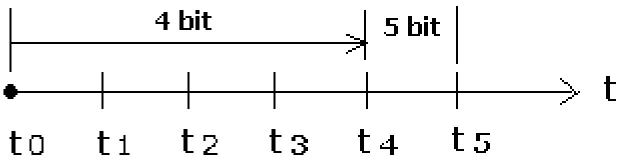
$$t_0 = 0$$
$$i = 1,2,3,4,5, \dots , N$$

For the time axis to select 1 bit of information on the interval equal to the quantum Δt_p:

$$\lambda_i = \frac{t_i - t_{(i-1)}}{\Delta t_p} = 1 \ bit$$

However, in contrast to a number axis, the information should at least be passed in time. In addition, this condition must be done in quantum mechanics.

Therefore, the amount of information is defined in the interval $[t_i - t_{i-1}]$ with regard to the transmission of information from the past to the future:



$$I_{max}(t_i - t_{i-1}) = \frac{t_i}{\Delta t_p}, \qquad (bit)$$

It turns out that the maximum amount of information on the interval $[t_i - t_{i-1}]$ is determined by the ratio of the amount of time to its quantum value.

The full maximum information about the events contained in the interval from zero countdown $t_0 = 0$ to the present time t :

$$I_{max}(t) = \sum_{i=1}^{n} \frac{t_i}{\Delta t_p}, \qquad (bit)$$

$$t = t_n$$

This formula gives the best possible information about events that are located in scale discrete time.

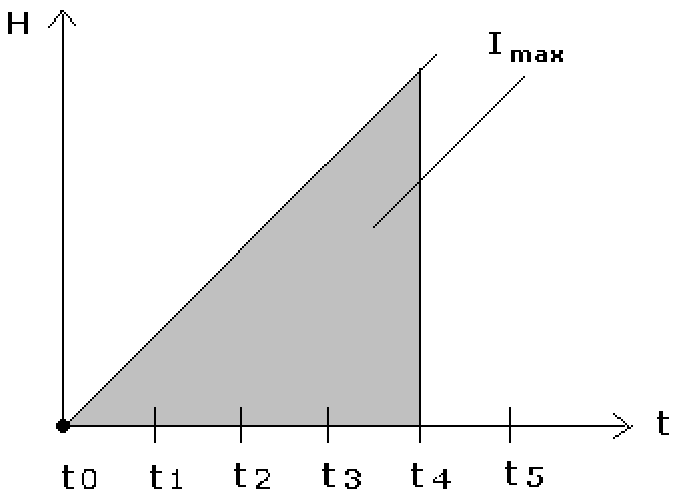
It can be converted to the following:

Let $n \gg 1$ and $t = t_n \gg \Delta t_p$, then

$$I_{max}(t) = \lim_{n\to\infty} \sum_{i=1}^{n} \frac{t_i}{\Delta t_p} = \frac{1}{(\Delta t_p)^2} \cdot \lim_{n\to\infty} \sum_{i=1}^{n} t_i \Delta t_p = \frac{1}{(\Delta t_p)^2} \cdot \int_0^t \tau d\tau \ ,$$

$$I_{max}(t) = \frac{t^2}{2(\Delta t_p)^2}$$

This is the formula of the fair, if time t is much more of its quantum interval Δt_p. The physical meaning of this formula is that the quantization axis, time on 1 bit, it can contain the maximum amount of information that can be transmitted from a previous state in the present.



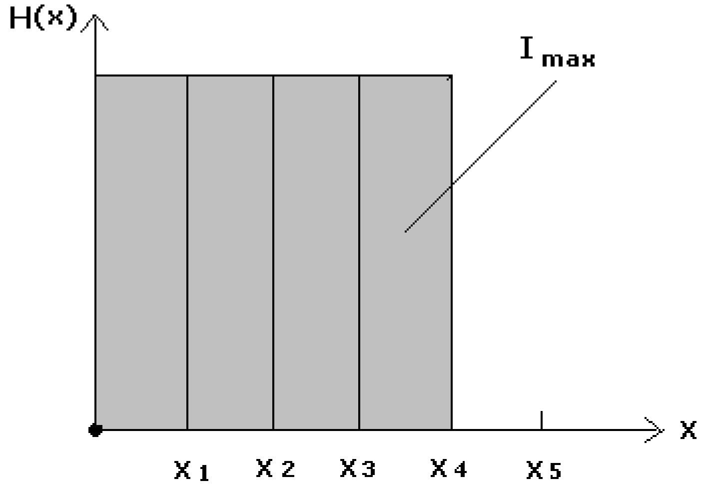
The figure shows the distribution of maximum density of information H in time, where quantization step 1 bit equal to the interval Δt_p.

$$H(t) = \frac{t}{(\Delta t_p)^2} \qquad (bit/s)$$

In principle, you cannot perform a replace operation of the reverse currents of time $t \to -t$, because the density of information becomes a negative value $H(-t) \to -H(t)$. Such a condition is obtained from the properties of information that should not be a negative value.

Let us now consider the distribution of information in discrete space on coordinate axes (x, y, z). Fulfilling the condition that step interval $\Delta l_p = l_i - l_{(i-1)}$ contains one 1 bit of information.

In contrast to the time axis of coordinates of the selected destination does not exist according to the principle of the isotropy of space. Therefore, the information in the maximum condition is distributed by coordinates evenly.



Maximum information is contained along the discrete spatial axis:

$$I_{max}(x) = \frac{x^2}{2(\Delta l_p)^2}$$

In three-dimensional space is:

$$I_{max}(x) = \frac{1}{2\left(\Delta l_p\right)^2} \cdot (x^2 + y^2 + z^2)$$

Maximum information contained inside a spherical shell of radius $r = \sqrt{x^2 + y^2 + z^2}$:

$$I_{max}(r) = \frac{r^2}{2(\Delta l_p)^2}$$

In thermodynamics and information theory there is a relation between information and entropy in the form of the ratio:

$$\Delta S = -\Delta I \cdot \ln 2$$

The increase of entropy in a system due to decrease of information in it.
For three-dimensional space, limited spherical shell minimum entropy will be:

$$S(x,y,z) = -\frac{\ln 2}{2(\Delta l_p)^2} \cdot (x^2 + y^2 + z^2)$$

For a time the same formula will be without negative sign in consequence of the fact that the physical processes in the isolated system develop with an increase in entropy and accumulation of information from the past to the present moment:

$$\Delta S(t) = \Delta I(t) \cdot \ln 2$$

$$S_{max}(t) = \frac{\ln 2}{2(\Delta t_p)^2} \cdot t^2$$

All physical processes occurring in space and in time , so the maximum entropy for a stand-alone system in time t and in space, limited spherical shell of radius $r = \sqrt{x^2 + y^2 + z^2}$ will be the sum of:

$$S_{max} = S_{max}(t) + S(x,y,z) = \frac{\ln 2}{2(\Delta t_p)^2} \cdot t^2 - \frac{\ln 2}{2(\Delta l_p)^2} \cdot (x^2 + y^2 + z^2)$$

$$S_{max} = \frac{\ln 2}{2(\Delta l_p)^2} \cdot (\alpha \cdot t^2 - x^2 - y^2 - z^2)$$

$\alpha = \left(\frac{\Delta l_p}{\Delta t_p}\right)^2$ - the coefficient quantization of space and time.

If space and time are discrete structure, the expression restricts the top on the entropy of all physical processes irrespective of their natural origin.
Is it possible to get a single geometric interpretation of space and time on the basis of this formula connecting the maximum entropy with coordinate parameters.

According to the wording of Boltzmann entropy is determined by probability, which is invariant value in all inertial systems of reference:

$$S = S^{|} = k \ln W = inv$$

So, my last equation becomes invariant form, i.e. the value of the maximum entropy of physical processes in all inertial reference systems the same way:

$$S_{max} = \frac{\ln 2}{2(\Delta l_p)^2} \cdot (\alpha \cdot t^2 - x^2 - y^2 - z^2)$$

$$S^{|}_{max} = \frac{\ln 2}{2(\Delta l_p)^2} \cdot (\alpha \cdot t^{|2} - x^{|2} - y^{|2} - z^{|2})$$

$$S_{max} = S^{|}_{max} = k \ln N_{max} = inv$$

Hence the amazing result associated with the geometric unity of space and time:

$$(\alpha \cdot t^2 - x^2 - y^2 - z^2) = \left(\alpha \cdot t^{|2} - x^{|2} - y^{|2} - z^{|2}\right) = inv$$

It is known that this transformation is the square of the interval in the Minkowski space. Therefore, the coefficient quantization α is a value that is the square of the speed of light.

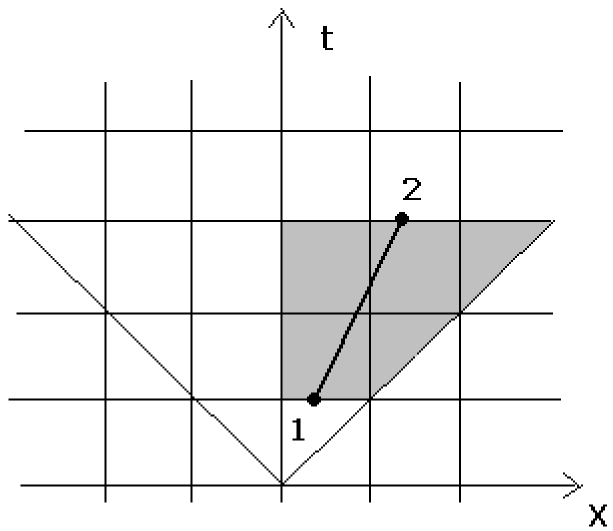
$$\alpha = \left(\frac{\Delta l_p}{\Delta t_p}\right)^2 = c^2$$

Hence, the maximal entropy takes the form of invariant in the form of a square of the distance in Minkowski space:

$$S_{max} = \frac{\ln 2}{2(\Delta l_p)^2} \cdot (c^2 t^2 - x^2 - y^2 - z^2)$$

In General quantization of space and time allows to combine the latest in a single entity in the form of a geometric object.

Such a Union was made possible, if you just consider the space and time as an information object with a discrete structure, where each cell capacity of 1 bit.



In an arbitrary metric space-time maximum entropy between the two events of 1 and 2 will be:

$$S_2^{max} - S_1^{max} = \frac{\ln 2}{2(\Delta l_p)^2} \left(\int_1^2 \sqrt{g_{ik} dx^i dx^k}\right)^2 \geq 0$$