the general science journal

The General Science Journal. March 2024.

Space-Time Asymmetry

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Abstract.-The empirical detection of the interaction between the vibrations of space (gravitational waves) and ordinary matter makes space a physical real object. This is not the case with time, which would be a physical magnitude measuring a universal and basic property of all physical objects related to the permanence of their successive physical states. As a consequence, a non-closed definition of space could be given, but not one of time. Under these conditions, the symmetry between space and time of the spacetime continuum is definitively broken.

Keywords: Spacetime continuum, discrete space, real space, discrete time, definition of space.

1. Space and time

The spacetime continuum is undoubtedly the most widely (explicitly or implicitly) used set in modern physics. It is the set of points in the three-dimensional space and instants in the one-dimensional time modeled by the Cartesian product $\mathbb{R}^4$, where $\mathbb{R}$ is the set of real numbers. For many physicists, neither space nor time have an independent real existence, they are only useful fictions to represent certain relations between real physical objects. Let us recall the famous words of H. Minkowski, spoken shortly before his death [10]

> Henceforth, space by itself and time by itself are doomed to fade into mere shadows, and only some kind of union of the two will preserve an independent reality.

On this subject I wrote not long ago [9]:

> And in our days we find on some physics well-known FAQ websites (obviously answered by *expert* physicists):
>
> > Spacetime is not a fabric, it is not material. Space is just an illusion, time is just an illusion therefore spacetime is just an illusion and a good way of simplifying the concept of general relativity to the public.
>
> This has also been the opinion of many relevant authors in the history of science and thought (particularly empiricists): G. Leibniz, D. Hume, C. Huygens, E. Mach, H. Poincaré, E. Borel, L. Wittgenstein etc. And of the vast majority of contemporary physicists. For example [12, p. 266]:
>
> > ... space and time, like society, are in the end also empty conceptions. They have meaning only to the extent that they stand for the complexity of the relationships between the things that happen in the world.

The spacetime continuum is a universal entity, at least theoretically, the same for all observers. It is an essential concept in contemporary physics, and not only in relativity theories. This universal entity is characterized by the fact that its elements are densely ordered, so that neither its points nor its instants can be contiguous, adjacent; between any two of them there is always the same non-numerable infinite number, $2^{\aleph_0}$, of points (instants). In other words, a proton occupies the same number of points as the entire three-dimensional universe, and takes the same number of instants to traverse one millimeter as it takes to traverse the entire diameter of the universe (Dimension Problem proved by G. Cantor [1, 5, 11, 13, 7, 4, 2, 3])

2. Space as a physical object

The empirical detection of gravitational waves, which has been made several times since 2015, should imply a change in the conception of space as a real physical object: These detections produce a change in the distance between the mirrors of the interferometers performing the detection, which is only possible if there is an interaction between two real physical objects: space and the interferometer. Mathematical artifacts do not reduce the length of physical objects. Or in Galileo's words: What does not exist does not act [6, p. 223]. Physical space can vibrate and be the transmitting medium of its own vibrations, which are of transverse, quadrupole type, of a great variety of frequencies and with a velocity of propagation through space itself of $299792458\,ms^{-1}$. This implies that the space must have the necessary physical properties to allow these vibrational and transmitting capabilities. Taking into account, in addition, the inconsistency of the actual infinite [8] (here you can see a very simple and brief demonstration), the physical space has to be discrete, with minimal indivisible units (qusits), perhaps of a Planck volume ($4.2 \times 10^{-96}\ mm^3$), and adjacent in all directions. Under these conditions of finite and discrete reality, a definition of space could be proposed:

> Space is a real physical object formed by a finite number of indivisible and contiguous units of non-null extent, which contains and possibly generates all the material objects of the universe, to which it does not offer any resistance to their movements and makes their mutual interactions possible.

To be real, there should be a space matter that is completely transparent to ordinary matter and different from ordinary matter and dark matter [9, pdf Link].

3. Time as a physical magnitude

Time does not seem to be a physical real object like space, but rather a magnitude that would measure a universal property of all physical objects: the degree of permanence in their successive actual states. Symmetry between space and time would then be impossible, because the former would be a physical object with detectable physical properties, and the latter would be a physical magnitude that measures a universal property of all physical objects.

The inconsistency of the actual infinity would have the same consequence for time as for space, time would also have to be discrete with indivisible and contiguous minimal units (qutits). The property that measures time is so fundamental and universal that only circular definitions would be possible:

> Time is a magnitude that measures the degree of permanence of any state of any physical object.

But permanence, duration and time are very close concepts, so the above definition of time is also circular.

4. Space and time in cellular automata

In the new conditions derived from the finiteness, discreteness and physical reality of space, together with the finiteness and discreteness of time, it seems inevitable to look for new models of physical reality outside the spacetime continuum. To begin the construction of such models, one could start from some that already exist, although they were generally not designed for this purpose. Among them, one could consider that of cellular automata (CA). In a model of the universe based on CAs, one could consider that:

1. The physical space is divided into indivisible units contiguous in all directions (qseats, cells in the language of CAs).
2. The state of each qusit is defined by a set of variables, and evolves according to a set of rules, in general very few and simple (action potentials?).
3. All qseats maintain their state for an indivisible unit of time (qutit), at the end of which they update their state according to the rules of the CA and the state of all other qseats with which it interacts.
4. The evolution of qseats can group them into jointly evolving sets (physical objects).
5. Interrelated qseats (physical objects) can spread throughout space and update their respective states simultaneously at each qbeat.
6. The evolution of physical objects governed by the laws of CA can give rise to the emergence of new laws relating the evolution of different physical objects (physical laws).
7. The whole universe would be part of the same CA, including measuring devices, observers and fields of consciousness.

As extravagant as the proposal of an CA-type universe may be, other models considered by modern physics are much more extravagant. CA-models would certainly be much simpler than any model based on the spacetime continuum, in which a simple line of a trillionth of a millimeter contains the same number of points as the entire three-dimensional universe: $2^{\aleph_0}$ points. In the case of a discrete CA-type universe, only a finite number of qseats, 7.64×10^{184}, would exist if they were a Planck volume in a universe 9 billion light-years in diameter, a number incomparably smaller than any infinite cardinal, as is the case of the power of the continuum $2^{\aleph_0}$.

In this type of models for the universe, some of the great enigmas of contemporary physics could be explained:

1. Quantum entanglement.
2. The problem of measurement.
3. The problem of change.
4. The interaction of qseats with measuring devices and with observers.

It would then be worthwhile to test models of this type to explain at least some basic aspects of the universe.

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