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The Substance of Physical Space

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Abstract.-Once the detection of gravitational waves is accepted, the fact that physical space must be a real object with the necessary properties to vibrate and transmit its own vibrations must be admitted. This short article starts the discussion on what must be the substance that constitutes this real physical space, taking into account its vibrational properties and, above all, its universal relationship with ordinary matter, which is undoubtedly of extraordinary importance for physics.

Keywords: space deformations, real space, space matter, discrete space.

1 Physical space is real and discrete

As almost everyone knows, gravitational waves have already been detected several times since 2015 [1, 2, 10, 12]. It is also well known that they are transverse quadrupole waves traveling at the speed of light through space itself. For the reasons given in [7, Link], the empirical detection of these ondulatory deformations of space demonstrates unequivocally that space can only be a real physical object with the necessary properties to vibrate, be the transmitting medium of its own vibrations and change the size (albeit microscopically) of material objects such as the arms of the interferometers that detect them. A conclusion that seems unquestionable if one accepts that what does not exist cannot vibrate or have empirically detectable properties or change the size of material objects.

But it happens that a considerable part of modern (20th and 21st century) physicists have defended the idea that neither space nor time are real, that they are only theoretical instruments useful for expressing the relative positions of physical objects in that fiction known as the spacetime continuum. For example, in 1902, E. Mach wrote (quoted in [4, p. 142]):

> Concerning the conceptual monstrosities of absolute space and absolute time, I could take nothing back.

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 [11, 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.

Presumably, this position on the ontological nature of space will eventually disappear, and the reality of physical space will be universally accepted, since observation and experimentation are the only valid ways to confirm scientific theories.

Relativistic physics considers other deformations of space: the inertial deformation (FitzGerald-Lorentz contraction) and the deformation caused by the presence of massive bodies (gravitational deformation). The former could only be apparent, because if it were real, material objects would have to have different sizes at the same time; or, for example, an elastic band could have stretched and contracted zones at the same time without any force acting on it [6, p. 69-70, Link]. The second type of deformation could also be explained in an alternative way, without the need to curve space, in this case using preinertia, a universal property of all physical objects, including photons, by virtue of which they all inherit the relative velocity vector of the reference frame in which they are set in motion [6, Part IV, Link]. According to this preinertia alternative, it would be the trajectories of photons that would be curved due to their gravitational interaction with massive objects, instead of having to curve the three-dimensional space itself, which is much more complex from all points of view (remember that physical nature bears the signature of simplicity, as has been recognized at least since the time of Galileo Galilei [3, p. 183-184]).

But for the deformations caused by gravitational waves, there seems to be no other explanation than the actual existence of the object vibrating and transmitting its own vibrations. The reality of physical space is an important first step for physics, which is followed and will be followed by others. To begin with, once the real nature of physical space has been accepted, it can be proved (now using the inconsistency of actual infinity [5, Link]) that such

space cannot consist of inextensive and densely ordered points, but of discrete, indivisible, contiguous units of non-zero extension (*geons*) [7]. A similar reasoning applied to time shows that it must also be formed by discrete, indivisible, contiguous units of non-zero extension (*chronons*), although time is not a physical object like space, but a universal magnitude related to the stability of the different states of the different objects, maybe related to the vibrational frequency of geons [7]. The next step is to discuss what the substance of physical space might be. To initiate this discussion is the purpose of this chapter.

2 On the substantiality of physical space

The formal consistency of the universe can perhaps be accepted as an inductive principle, but it can also be formally demonstrated as a theorem from another even more fundamental principle, which establishes the directional evolution of the universe (in the direction that increases its entropy/isotropy). A principle that has overwhelming inductive evidence. In this consistent universe scenario, a first fundamental discussion begins here about what the space matter should be, given what we already know about ordinary matter, about space itself, and about its interaction with ordinary matter. It also takes into account the inconsistency of actual infinity, a key issue for physics that is virtually never considered. On the basis of these various supports, it is possible to draw the first conclusions about the materiality of real physical space and some of its most important physical consequences related to ordinary matter, time, motion, and the own evolution of the universe. Thus, without being exhaustive, the following points can be emphasized:

1. Taking into account the Principle of Inertia we can affirm that the space matter does not have gravitational effects on ordinary matter. Therefore the space matter cannot be like dark matter because the latter does have gravitational effects on ordinary matter. We would have, then, three kinds of matter: ordinary matter, dark matter and space matter.

   Comment: Since gravitational waves change the length of the arms of their detectors (interferometers), one would have to admit some interaction of the vibrations of physical space on ordinary matter. Or some other explanation of the phenomenology of detection would have to be given, perhaps based on the discrete nature of space and time.

2. On the contrary, the space matter is sensitive to the presence of ordinary matter: its properties are altered in the vicinity of material objects, the more so the more massive those objects are, and the closer the regions of space under consideration are to those massive objects.

   Comment: These space deformations (gravitational deformations) affect other material bodies that are different from the material body that produced them. Therefore, we can say that space matter allows ordinary material objects to interact with each other at a distance.

3. The space matter can vibrate and transmit its vibrations at a speed of 299792458 m/s (gravitational waves).

   Comment: Vibrations of the space matter could be due to reversible periodic deformations of its discrete units (see item 10 below) or to periodic changes of state of these same units.

4. Electromagnetic waves propagate through the space matter, so this substance must have the necessary physical properties to be able to transmit gravitational and electromagnetic waves at the same speed of 299792458 m/s.

   Comment: The coincidence of these two velocities could indicate the existence of a maximum velocity of one qseat (quantum unit of space) per qbeat (quantum unit of time).

5. The space matter is virtually transparent to the entire electromagnetic spectrum, from gamma rays to radio waves.

6. The space matter has certain electrical and magnetic properties, such as magnetic permeability μ_o and electrical permittivity ϵ_o, which define the speed of light c in (supposedly) empty physical space: $c = (\mu_o \epsilon_o)^{-1/2}$.

7. The space matter must be able to exhibit and propagate different values of electric and magnetic charges.

8. The substance that makes up physical space must have the properties necessary to manifest in its bosom variable intensities of the four fundamental forces (force fields) that make possible all the physical interactions of all material objects (remember that the interior of atoms is occupied in its practical totality by physical space).

   Comment: The physical properties of space matter make possible the formation, maintenance, and evolution of all material objects.

9. Does the space matter have anything to do with dark energy?

10. For the reasons given in [7] (inconsistency of actual infinity), and also taking into account the consistent nature of the universe, physical space must be formed by minimal indivisible units, contiguous in all directions and of non-zero extension, units which we will provisionally call qseat. Thus, as in the case of ordinary matter, energy and all kind of charges, the space matter is also quantum in nature.

    Comment: The same reasons for the formal consistency of the observable universe allow us to prove that time must also consist of minimal indivisible and contiguous units [8], which we will call qbeats for the time being. And for the same reasons, motion must also be discrete.

11. The consistency and universality of physical laws requires the universal existence of some relation between the discreteness of space matter and the discreteness of ordinary matter, energy, electric and non-electric charges.

    Comment: Qseat, the discrete units of real physical space, could not only contain the discrete units of ordinary matter, but be their generative cause.

12. The fundamental properties of geons must be the same in all directions of space, and their spatial distribution must be homogeneous, both of which are necessary conditions for the universality of physical laws in an isotropic and formally consistent universe. The space matter must therefore be homogeneous, isotropic, and stable as such a matter.

13. Real physical space, consisting of the same homogeneous and isotropic space matter, will be the same for all material objects contained within it. Thus, physical space is universal and absolute.

14. If a qseat were the size of a Planck volume, the observable universe would consist of $\approx 1.85 \times 10^{184}$ geons, and a proton would occupy $\approx 1.44 \times 10^{59}$ geons. All of them finite numbers.

    Comment: In a consistent universe, there can be no infinite sets (actual infinity, not potential infinity). Consequently, and whatever it is, the number of geons in space will always be finite, which greatly simplifies their evolution.

15. Since all the ordinary matter of the universe is contained in physical space, it makes sense to speak of the material content of geons. Even of the generation of ordinary matter within the space geons.

16. Since ordinary matter evolves (changes), so must the material content of geons.

    Comment: A magnitude can be defined to measure the persistence of the changing material content of geons: *time*. The same magnitude that, from the point of view of material objects, would measure the persistence (stability) of their states, is intimately related to the persistence (stability) of the material content of geons (their vibrational frequency). In this sense, time would be perhaps the most essential magnitude in the evolution of the universe.

17. For the same reasons of formal consistency as in the case of space, time must also be discrete, and its units as such units must be indivisible, contiguous and of non-zero extension. It seems appropriate to call them chronons.

18. The universality of the physical laws applied to the evolution (history) of the universe requires the homogeneity of the chronons towards the past and towards the future. The discrete units of time should therefore be homogeneous and isotropic in both directions.

    Comment: The homogeneity of space and time is what makes possible the geological Principle of Actualism-Uniformism [9], which is insistently and without exception recorded in all the rocks of the Earth. This record, in turn, is an impressive proof of the Principle of Directional Evolution of the Universe and of all its formal consequences.

19. The isotropic sequence of homogeneous chronons is the same for all material objects. Time is therefore an absolute and universal magnitude that measures the persistence of the state of geons and the ordinary matter they contain.

20. For the same reasons of formal consistency as in the case of space and time, motion must also be discrete, which means that, at least for a qbeat, nothing moves in the universe.

21. The motion of material objects occurs THROUGH the space matter, or what is the same, THROUGH the universal and absolute physical space. It is an absolute motion because time is also an absolute magnitude.

22. Preinertia and the lack of sensory and instrumental perception of geons (at least for now) make the detection of absolute motion impossible.

    Comment: Preinertia is a universal property of all physical objects (including photons), by virtue of which all objects inherit the velocity VECTOR! of their proper reference frame when they are set in motion, which is why it is impossible to detect the absolute motion of a reference frame using only the objects set in motion in that reference frame. The different absolute velocities of the different material objects give rise to the different relative velocities of the different material objects. Relative velocities are the only velocities that can be observed, detected and measured.

23. The inertial deformations of space and time described by special relativity would be only apparent, as is the case with refractive deformations.

24. The existence of a maximum speed of one qseat per qbeat determines the existence of a maximum insurmountable speed for all material objects, including photons. This could be the speed of gravitational waves and electromagnetic waves through real physical space.

25. The principles of special relativity are therefore operational, but not fundamental. They are tools for local explanations of the local observations in a local reference frame, and with mathematics based on the infinitist continuum, which is also inconsistent.

26. From the point of view of fundamental physics, special relativity is neither necessary nor consistent.

27. The real physical space constituted by geons could be reversibly deformed if these geons

were reversibly deformable, and their deformation could be propagated through the successive geons.

Comment: It can be proved that the points and instants of the spacetime continuum have no extension (duration) and are densely ordered (between any two of them there is always the same number $2^{\aleph_\circ}$ of other different points). There is no contiguity neither of points nor of instants (these are the formal causes of Zen's dichotomies). Under these conditions it can be proved (apart from the inconsistency of the continuum itself) that the spacetime continuum cannot be deformed [7].

28. The gravitational deformations of space may not be such deformations, but consequences of the gravitational interactions of photons with massive objects, which would produce the deformation of photon trajectories, a deformation much simpler than the deformation of three-dimensional space.

Comment: A physical theory such as general relativity that is based on an inconsistent mathematical concept (such as the actual infinity that defines the space-time continuum) cannot be consistent; it cannot be a fundamental theory. At best, it would be an operational theory, explaining local observations made and interpreted in a particular mathematical framework, which, being inconsistent, cannot be applied to a complete universe that is formally consistent.

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