Abstract

Our main purpose here is to study some qualitative aspects of space and time. These include the notion of space and time regarded as the containers of respectively bodies and events, the divisibility of space, and the unrepeatability of events. We thereof argue that the ideas of an empty space, portions of empty space and a homogenous space are misleading when they are applied to realized space, and that they are therefore not suitable for space as a condition of corporeal world (as it is often assumed). We also show that smallest (indivisible) and “final” (“ultimate”) parts of space and bodies have, at most, a conventional character, and not a “fundamental” one (as it is usually claimed). With respect to time and events, analogous conclusions follow. However, we claim that between space and time there exist rather big qualitative differences, which make time’s nature much more difficult to grasp than that of space. In this sense, we discuss the impossibility of repetition of events and some of its applications in modern science, notably, probabilistic and statistical science. Some other implications of this study in conceptual (“philosophical”) aspects of modern physics are briefly discussed, such as the “timeless” interpretation of general relativity, the notion of space-time, among others. Finally, some considerations about the usual conception and the scope of modern science in general, and modern physics in particular, are addressed throughout the article.

Key words: Space, time, qualitative aspects, conceptual modern physics, events, divisibility of extension.
1 Introduction

Nowadays, the so called philosophical aspects of scientific theories are largely neglected. Scientists spend most of their efforts on the applications of these theories or (following the empirical-inductive method of modern science) on trying to formulate more or less general theories from specific experimental facts, overlooking, in this way, the philosophical part in general, and completely neglecting the true deductive reasoning in particular. In our opinion, this tendency has reached a worrying level: the present scientific point of view is mainly characterized by seeking to bring everything down to quantity anything that cannot be so treated is left out of account and is regarded as more or less non-existent. Currently, people commonly think and say that anything that cannot be indicated or represented by numerals, or, in other words, cannot be expressed in purely quantitative terms, for that reason lacks any scientific value; and this assumption predominates not only in physics, but in all modern science; even the psychological domain, with the partisans of psycho-physiology, is not beyond its reach. As a consequence, this point of view leaves aside most of the qualitative aspects of the object under study, thus, moving away from its nature or essence.

We believe this attitude to be very unfortunate, since it strongly disregards and jeopardizes the cognitive value of science, which should be its raison d’être. Science should try, as far as possible, not to neglect the qualitative aspects of things, which express better, than a “mere” quantitative description, the nature of the object under study. In this sense, our general aim here is to bring back and treat, in a clear and concise way, some qualitative aspects of space and time, as well as the role these determinations play in the corporeal

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2 Let’s remark in passing that the research work performed by scientists is characterized, as most of the actions carried out in modern society, by a feverish haste; and whatever the importance of this fact may be, it finds its main causes in some of the qualitative aspects of time.

3 This tendency is very well expressed by some words of [Kelvin (1891)]: “In physical science the first essential step in the direction of learning any subject is to find principles of numerical reckoning and practicable methods for measuring some quality connected with it. I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the state of Science, whatever the matter may be.” (p. 80-I).”

4 In that respect, one should remember the preponderant role played by the measurement process in the operational definition of concepts suggested by P. W. Bridgman.
world. In particular, our main concern is to present the idea of space and time as containers of, respectively, bodies and events. The divisibility property of space, and the unrepeatability of events will also be studied to some extent. Alongside these considerations some conceptual and philosophical aspects of modern theories of physics are contrasted with these ideas of space and time. We believe that this point of view can shed light on some errors and confusion generated around some basic concepts of modern physics.

At this point, some precisions about the concepts of “quality” and “quantity” deserve to be established, specially because these terms play an important role in this work. We assume, however, that, because of the considerations mentioned above, the reader is more familiar with the notion of quantity than that of quality. The quality refers to the Aristotelian concept of εἰδος which, besides the meaning of “idea”, is also used to mean “species”, that is, a nature or an essence common to an indefinite multitude of individuals. However, this specific nature is of purely qualitative order, because it is truly “innumerable” in the sense that it is independent of quantity: being indivisible and entire in every individual belonging to a given species, it is then unaffected by the number of those individuals, “plus” and “minus” not being applicable to it. Since εἰδος is “opposed” to ύλη, we can say that the quantity refers to the latter. We observe then that in some sense quality and quantity are correlative; they are, to some extent, complementary terms. In other words, quality and quantity refer to, respectively, “essence” and “substance” used in a relative sense, that is, as the “form” and the “materia (secunda)” of the scholastic philosophers. One can realize this when one considers, on the one hand, that the essence is the principal synthesis of all the attributes that belong to a being and make that being what it is, and that attributes and qualities are really synonymous (it may be observed that quality, in this sense, can be considered as the content of essence, if such an expression is allowable); and, on the other hand, that the substance (substantia in Latin) is “that which stands beneath”, a meaning also attached to the ideas of “support” and “substratum”. It is in this sense that we mean that the explanation of things—or their “fundamental” aspects—should not be sought on the substantial (quantitative) side, but on the contrary it should be sought on the essential (qualitative) side. Finally, when we talk about the explanatory value of something, it is this meaning that one must bear in mind.

Before going into the detail of the main considerations, in what follows we present a brief survey of some of the most relevant ideas (in our eyes) about space and time in western philosophy and western science, leaving aside very

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5 In order to support these considerations, in the sense just explained, one could also talk about the “act” and the “potency” in the Aristotelian sense. In much less usual terms, one could talk about “nāma” and “rūpa” from Hindu doctrine; or, understood in a relative sense, “Tien” and “Ti” from “Chinese” doctrine.
important thoughts and points of view, such as Hindu and Arabian doctrines[6].

1.1 A brief historical survey of space and time ideas

The history of space and time ideas is quite intricate and complex. Our main interest is, then, to familiarize the reader with this history, and not to give a complete nor exhaustive review of the subject. At the same time, since this article is closer to philosophy of science than pure science (as understood nowadays), we shall focus rather on the philosophical development of space and time ideas, treating some modern scientific considerations and implications throughout the main text, and especially in the appendix, where the notion of “space-time” is considered at some length.

Roughly speaking, we can visualize three main philosophical positions about both space and time:

1. as realities by themselves, independent of “things”;
2. as properties of “things”;
3. as relations among “things”, dependent on “things”.

Most relevant philosophical points of view about space and time can be situated, as one can see from the following considerations, in one or a combination of these positions.

Space

We begin this basic review[7] by considering space. Given the framework defined above, we begin our journey with the aristotelian point of view[8]. Aristotle considered space mainly from the “place” point of view; things are made of space which does not mean that they are modes of a spatial continuum, because, according to the concept of “place”, it is not possible to conceive things without their space, the space cannot be only an empty receptacle. In contrast, Greek atomists (like Democritus and Leucippus) conceived space as “the vacuum” in between atoms; space is not something, since only atoms are “things”. Theophrastus, an Aristotle’s student, considered space, not as

[6] Coomaraswamy (1993) has a very interesting work comparing different points of view about time and eternity in western, eastern and middle-eastern doctrines. We are not aware of the existence of an equivalent work treating the notion of space.

[7] To do this review we took as guideline the dictionary of philosophy from Ferrater (1980).

[8] We begin with Aristotle because it is from him that more detailed works on physics (in the ancient sense of natural science in all its generality) are known, at least with regard to ancient western philosophy.
reality in itself, but as something defined by positions and the order of bodies. In his turn, one of the Theophrastus’ successors, Strato of Lampsacus, perhaps influenced by his theory of void (whose main postulate is that all bodies contain a void of variable size), proposes to consider space as something completely empty, but always filled up with bodies. Within the hellenistic schools of thought, these were the four most influential streams concerning the notion of space. The Stoic conception of space, influenced by these streams, was founded in the idea of a continuum within which there are positions and an order of bodies. We leave the ancient western philosophy with a neoplatonist philosopher, Damascius, who considered space as a “matrix” inside which there are all possible bodies’ positions and the relations between them.

During the Middle Ages, there was an important development of science,[9] notably by the scholastics (who, by the way, also developed metaphysics, which was regarded as being above all particular sciences). Their ideas about space were closely related to those of Aristotle, though there was the distinction between real space and imaginary space: real space is “finite”, having the same limits as the universe of things; it is the space of bodies. Imaginary space is potentially “infinite”, it is the space which extends beyond the actual things or, in other words, it is the space which contains other possible things than those of our present world. Scholastics also considered the problem of the independence or dependence of space with respect to bodies. St. Thomas of Aquin is an important philosopher with respect to all these considerations.10

From the Renaissance to the present, more quantitative, empiric, or “subjective” aspects of space have been considered, in contrast with what we could call the qualitative aspects of space. In this sense, these kinds of considerations are less important for the present work. From this long period, we will treat, however, those ideas which represent the most interest to us.

In Renaissance times and the XVIIth century, the idea of space thought of as an homogeneous and indifferent extension showed up: space is an “extended thing” (res extensa). Space was considered as the universal container of “physical bodies”. Besides homogeneity, space was regarded as isotropic, continuous, unlimited and three-dimensional. These are the most representative features of space as conceived at this time. From this period the following thinkers stand out: Bernardino de Telesio, Galileo Galilei, René Descartes, Baruch Spinoza, Gottfried Wilhelm Leibnitz and Isaac Newton. But, it is Newton and Leibnitz who are particularly representative of this epoch:

9 This development should not be understood in the empirical and quantitative sense of modern science.
10 St. Thomas also treats the question of time from a “physical” and theological point of view (see below). These considerations can be mainly found in his Summa Theologica, and, to a smaller extent, in the Summa Contra Gentiles. Of course, they are also addressed in his comments to Aristotle’s work and in Opuscula philosophica.
Newton conceived space as an absolute reality and as the ground of any measurement. Space is a reality in itself, independent of the objects situated in it and their movements: movements are relative, but space is not. On the contrary, Leibnitz says that space is not absolute, nor is it a substance; it is not an accident of the substance either, but it is a relation: as a relation, space is an order, the order of coexistent phenomena; there is no real space outside the material world, space itself is something ideal. For Leibnitz, motion exists only as relations among objects. On the other hand, Newtonian space provides an absolute reference frame about which objects can have a motion. Newton’s ideas have prevailed in the scientific community ever since, except for some like Ernst Mach, who is considered the continuator of Leibnitz’s ideas (see the appendix for more developments in this respect).

In the XVIIIth century, Immanuel Kant is the most representative thinker who dealt with the concept of space (and time). Kant did not adhere completely either to Newton’s ideas or to those of Leibnitz. He tried to solve this debate by formulating his own perspective, mainly an “ideal-sensorial” point of view which, by the way, has characterized many other philosophical positions ever since. This point of view is characterized by taking into account almost exclusively the aspects of space (and time) as perceived by the human being. Kant argues that space is both pure form of (sensible) intuition and pure (a priori) intuition. From the “empirical” perspective, space is not an empirical concept which has been derived from outer experiences; it is the subjective condition of sensibility, under which alone outer intuition is, on the contrary, possible for us; space represents properties of things as they appear to us but not properties or relations of things as they are in themselves. Space is then not objective. From here, space is a pure form of intuition because it must precede and structure all experience of individual outer and inner states. On the other hand, from the “transcendental” perspective, space is an immediate (not sensorial) representation; space is a pure a priori intuition, because it represents a single individual rather than a class of things, and it is an a priori intuition because it is presupposed in order to “understand” (experience) things.

We stop here our historical considerations about space, leaving modern physics conceptions for comments in the remaining sections and, in particular, for the appendix. We proceed now to make a similar survey for time.

**Time**

During ancient and medieval times, it seems that the concept of time has been relegated in favor for that of being. This is quite “natural” when one realizes that *being and becoming are intimately related*. Aristotle, in particular, used the concept of movement to reach that of time: time and movement
are perceived together; therefore, time has to be movement or something in
time has to be the other
For Aristotle (Physics, 220\textsuperscript{a} 24 – 220\textsuperscript{a} 26) “time is the number of
movement in respect of the before and after; and, being the number of what
is continuous, it is itself continuous.” (see e.g. Ross, 1998, p. 387).” Aristotle’s
contributions have exerted, apparently, a big influence ever since. The Stoics,
for example, followed his ideas, but with a crucial difference: time is made
of something like “indivisible temporal particles”, a strange conception for
that epoch. Two main “physical” positions, since Aristotle’s thoughts, about
time can be roughly distinguished: the “absolutism” and the “relationalism”
points of view. Roughly speaking, the absolutists conceive time as a complete
reality by itself; the relationalists deem time as a relation and not as a reality
in itself. On the other hand, there is the position represented by thoughts
like those offered by Plotinus, a neoplatonist who considered that time could
not be only a measure of movement, since it has to have a self-reality with
respect to movement. Time is, for Plotinus, a mobile image of “eternity”:
the soul leaves time when it goes to the intelligible, but so long as this does
not happen, the soul lives in time and even with time; time is the successive
prolongation of the soul’s “life”. These little considerations have taken us far
from the scope of the present introduction. We wanted to display it anyhow,
because it offers an important, influential, and representative alternative to
the Aristotelian point of view. More or less in the same spirit as Plotinus, we
have the Augustinian conception of time\textsuperscript{12}. Saint Augustine says that time
is not something that we can grasp “externally”, one has to go to the “soul”
to do so. Saint Augustine was not only concerned by the understanding of
time, but also by the reality time could have with respect to Creation. The
latter can be called the theological conception of time. These kinds of worries
(including the problem of eternity) lasted throughout the Middle Ages. During
this period, however, there were also the “physical” conceptions of time, which
were closely related to Aristotle’s ideas. The problems of “before” and “after”
were (as in ancient times) also addressed during these times.

After the Middle Ages, conceptions about time were centered around the ques-
tion of how time could be understood with respect to “physical bodies” (or
“matter”) or “natural phenomena,” and, above everything, how time could
be measured (in the modern sense); in one word, just as for space, attention
was focused on more quantitative aspects of time, thus preparing the ground
for the tendency of modern science. Time as a property of things was almost
completely disregarded, since it was considered that it should be something
“external”. Attention was then centred on time as a reality in itself (indepen-

\begin{itemize}
  \item \textsuperscript{11}In the same work Aristotle also says (219\textsuperscript{b} 2 – 219\textsuperscript{b} 8) “‘number’
may mean either that which is numbered, or that by which we number it; time is number in the
former sense.” (see e.g. Ross, 1998, p. 386)."
  \item \textsuperscript{12}Book XI of Confessions is particularly devoted to the conception of time.
\end{itemize}
dent of things), and time as a relation; time was used extensively as a measure of duration. It is usually said that Isaac Newton, together with Samuel Clarke, supported the former position; while Gottfried Wilhelm Leibnitz (and later on Ernst Mach) were advocates of the latter. As in the case of space, during this epoch, time was required to have some very specific properties; it should be, for example, continuous, unlimited, non isotropic (that is, with only one dimension and only one direction), homogenous, and it should “flow” uniformly (always at the same “speed”). These properties were not always all required. It was mostly the physicians and mathematicians who, in order to extract specific quantities, were more concerned with the mathematical representation of these properties.

The Newtonian conception was remarkably influential, and remains so to this day. Time, for Newton, is absolute; it is independent of things, i.e., while things change, time does not. In this sense, the changes of things are changes with respect to a time which can be taken as an empty, homogenous, temporal reference frame. This is in complete analogy with the Newtonian conception of space. However, for Newton, time also flows and moves in only one direction and uniformly. On the other hand, for Leibnitz, time is the order of existence of things which are not simultaneous; time magnitude is what we call duration. We end this historical survey by adding that Kantian conception of time is very closely related to the Kantian conception of space.

This article is organized as follows. In Section 2 we study the notion of space as the container of bodies, which allows us to clarify the concepts of empty space, homogenous space, and holed space; the divisibility of space, being a very important qualitative aspect of space, is also discussed to great extent. In Section 3 somewhat similar considerations are made with regard to time and events; in addition, we offer a discussion on the repeatability of events and statistics based on some qualitative aspects of time. Section 4 contains some short considerations about movement and its relationship with space and time. The conclusions and perspectives of this work are given in section 5. Finally, in the appendix, we give a brief summary of the notion of “space-time” together with a short discussion on the subject, and, especially, on some modern interpretations of general relativity. In addition, we scatter throughout this work short-general comments about some aspects of space and time (and related subjects) as described by physicists, and about the way modern science is generally conceived.
In this work, space is regarded as the realized space or “physical” space, that is, the space that actually makes part of the corporeal world. In other words, space is for us, simply, the place where the possibilities of corporeal order occurs. Space is the container of bodies. Still another way of saying the same: space constitutes the “field” within which corporeal manifestation is developed. In this sense, bodies constitute the content of space, but this is not the only property which defines them (as we shall see afterwards). There cannot be space without bodies (and vice versa), because this would imply a container without content, that is, something that cannot exist effectively: the relation of container to content necessarily presupposes, by its very nature as a correlation, the simultaneous presence of both of its terms. Thus, the container and content are two correlated concepts (one cannot exist without the other, one implies the other). This does not mean however that we can reduce one to the other, they are of a different nature. In particular, in this respect, the correlation between bodies and space should not be confused, as it is often done, with an identity. However, this does not mean that one cannot include them in a common framework; in other words, even if space and bodies are very distinct things, this does not mean that we cannot find a common principle from which one can explain them, as the fact that they are correlated gives some indication.

To give a familiar example of correlation, consider the following. When one talks about a son, one is implicitly talking about the idea of a father and vice versa: whenever one talks of a son, anybody will know that, unavoidably, there is (or was) a father. These two ideas (father and son) are inseparable, there cannot be a son without a father, nor a father without a son; but the two functions, the two beings, are completely different (in some sense, one could say that they are complementary). Therefore, even if one idea cannot exist.

\[13\] In this sense, space, realized space and “physical” space are taken as synonymous. When necessary, we will clearly distinguish and characterize other spaces like geometric space (that is, the space containing all the geometric forms (or figures)).

\[14\] And the phenomena of which they are the support, that is, the corporeal phenomena.

\[15\] As Descartes tried to suggest.

- At this point, it is worth mentioning that a third condition determining the corporeal world, besides space and time, is what the scholastics called materia secunda or the “substance” (in the aristotelian sense), both relative to the corporeal world (some hints about this subject can be found in Saint Thomas Aquinas when he talks about “materia signata quantitate”). It would be of some interest to study this third condition as a constituent of the corporeal world and to establish the relation between this materia secunda and the “matter” studied by physicists.

\[16\] Correlation: reciprocal relation between two terms or notions.
without the other, they are completely different. What is more, in this case, they *have* to be quite different in order to allow a correlation between them.

This example highlights the correlation between two concepts: father and son coexist as concepts (they are implied mutually and, in this particular case, they are complementary). On the other hand, it leaves out the idea of coextension that, as we shall see, is proper (but not exclusive, since *any* pair container-content presents it) to space and bodies.

**Space is coextensive with bodies.** From the previous ideas one can show that this is indeed the case. According to the definitions given at the beginning of this section, strictly speaking, if one wants to talk about space, one has to necessarily associate it with bodies. The only function of space is to contain bodies: it is the “field” available for the manifestation of the corporeal possibilities. Therefore, for example, if we say that between this article and the reader there is some space, then between this article and the reader there have to be bodies. We arrive thus to the conclusion that the idea of space as the container of bodies leads us to the idea of coextension of space with bodies and, evidently, if they are coextensive, they are coexistent with respect to the corporeal world. The concept of coextension is more restrictive than that of coexistence, and therefore the former implies the latter. If something is coextensive with something else, they are necessarily coexistent. On the other hand, if they coexist, they are not necessarily coextensive (as in the example of father and son). These conclusions will be enriched with the considerations developed in the rest of the section.

There are some other interesting ideas that can be treated from this perspective:

**Homogenous space.** This is a very usual term; in particular, it is basic in many theories of modern physics. A homogenous space can only be conceived as a space without bodies, and even without geometric figures.\(^{19}\)

\(^{17}\)One could “translate” the coextension (in this case of temporal character) in the son-father correlation by saying that, for example, both (living) beings have to coexist in this world, something that of course is not necessarily the case.\(^{18}\)

\(^{18}\)Evidently, we do not only refer to the well known empirical verification that there is air filling up this space. Fields (in the sense of modern physics), radiation, etc. are included in the concept of bodies or corporeal possibilities.\(^{19}\)

\(^{19}\)For example all theories using Euclidean *space*, which include Newtonian mechanics and special relativity (see appendix).\(^{20}\)

\(^{20}\)In general, figures would introduce a heterogeneity to space (recall, the space with geometric forms is the geometric space). Below, we shall see how less determinate spaces, like geometric space, could be used to understand some aspects of the
or, otherwise, as a space with the same (and identical) body everywhere (for example, in modern terms, “a homogenous field”). Clearly, none of these possibilities occur in realized space, since it contains a diversity of bodies. The idea of a diversity of bodies can be sustained by, besides the evidence of this fact, the principle of indiscernibles discussed in Sec. 3.1 and consideration therein developed. In this sense, the only presence of bodies suffices to determine qualitative difference between the parts of space they occupy. In addition, if we consider the size (the magnitude) as the quantitative aspect of space, and, on the other hand, we observe that a homogenous space presents the only property that its parts are indistinguishable one from another by any characteristic other than their respective size. Then, a homogenous space would amount to a space denuded of any qualitative element, that is, a “purely” quantitative space; but, again, because of the presence of bodies, this is clearly not the case of realized space in the corporeal world. Therefore, the homogeneity cannot be a property of physical space, as it is considered by the physical theories just mentioned.

**Empty space.** People often talk about empty space, that is, a space without any kind of body (or even any corporeal possibility), but this is meaningless within the framework here established, simply because space is coextensive with bodies. In other words, the conception of an empty space would lead back to the conception of a container without content, but this is something that we have discarded from the very beginning: the relation of container to content necessarily presupposes, by its very nature as a correlation, the simultaneous presence of both of its terms. Moreover, an empty space can be conceived of as a space denuded of any qualitative aspect (“qualitative emptiness”), but, clearly, this can have no place in the corporeal world, since the corporeal world presents a multitude of qualitative aspects. From the previous paragraph and these considerations, we also learn that the hypothesis of an empty space implies the hypothesis of a homogenous space.

**Space with holes or holed space.** This space is usually conceived as a space with “holes” where there is not any kind of body (“empty holes”); and what we have said about the coextensivity of bodies and space should be enough to dispel this idea: when we talk about space, we have to necessarily relate it to bodies. Otherwise, we insist, we would be forced to bring out the hypothesis of portions of space devoid of any qualitative element (i.e.,

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21 To this the objection might perhaps be raised that there exists the hypothesis of having a “homogenous field” (in modern terms) spread all around the space. But if this is a homogenous field in all respects (in order to keep up the homogeneity hypothesis), what is then the quality aspect bring about by it?
portions of space fitted up solely with the size aspect), which are immediately rejected by the considerations offered above. In fact, each of these portions is a particular case of the empty space considered above. Then, the idea of portions of space without bodies has no sense for us either.

In physics, one is supposed to explain or at least to describe the “physical” space (in the sense described here). However, the discussion offered above should be enough to realize that describing the corporeal world as “living” in an empty space or a homogenous space or even a holed space, as is very often done in the theories of physics, is meaningless: these ideas cannot be applicable in any precise sense to the corporeal world, that is, the world of which modern physics tries to provide the explanation.

We believe that some of these ideas come from considering space and bodies as two things with separate and independent existence. In particular, as one can already guess from the previous considerations about the properties of space, there is rather a tendency to deem the existence of space as independent of that of bodies, as the following usual “logical chain” shows: “let’s study the space without bodies; then, once we have the space under ‘control’, let’s study bodies; once (the bodies) under ‘control’, as a final step, let’s put bodies in space and see how everything works together”. From here, one can easily go wrong and consider portions of “empty space” between bodies or even “empty space”, as if the space was already given before introducing bodies into it. But,

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22 Recall the considerations about the notion of explanation given in the introduction. In this work we briefly discuss the explanatory capacity of modern science, in particular, in Secs. 3.1 and 5, and the appendix.

23 It would be of some interest to explore which of the conclusions drawn in modern physics from the consideration of an empty, homogeneous or holed space remain within the framework presented here. For example, a homogenous space implies conservation of linear momentum. We leave these kinds of considerations for future works.

24 On the other hand, as it is well known, it is generally accepted that bodies take “something” from space, they depend in some way on space; for example, bodies take up space (they have a volume).

In this respect, some people working in the theory of general relativity would say that space is determined by bodies. However, in that theory, it is not the existence of space which is determined by bodies, but its “shape” (its geometric characteristics). By the way, the concept of empty space is accepted in this theory: the Schwarzschild solution, for example, is a “vacuum solution with a spherical symmetric source”; or does this mean that the space is filled up with “gravitational field”? Would it then still be appropriate to talk about “empty space”? (for more considerations about this we refer the reader to the appendix). Now, in this work we have never stated that space is a (logical) consequence of bodies, but, as previously indicated, it is a matter of correlation (container-content, in this case) which gives coextension as result.
this is incompatible with the ideas presented here: we cannot treat space and bodies as two independent pieces and then bring them back together to try to describe or to understand the corporeal world!

On the other hand, one could still wonder what the nature of space is or what the properties of a space without bodies could be. In such a case, one must consider space, sort of to say, by itself (that is, a space without bodies) and study it; one could take, for example, geometric space. However, when applying the results obtained to the “physical” space, one must not confuse less determinate spaces with the “physical” space (this is coexistent and coextensive with bodies). The latter inherits properties from geometrical space (or other less determinate spaces). On the contrary, if geometric space does not present some properties, this does not imply, in general, that these features are absent in the “physical” space. In what follows we see an example of this kind of confusion, and an important example where a property of space can be used to understand some aspects of the corporeal world (ours).

**Important conclusion.** So far we can formulate the following important statement: *Realized space does not extend beyond the corporeal world, and inside the latter, physical space contains all bodies which are spread out everywhere.*

Another presently less widespread idea is that of confounding bodies with space. On the contrary, as we have already argued, space and bodies are two distinct things. It is true, bodies are extended because they participate in the extension of space; who says corporeal says necessarily extended. But, it is important to notice that the spatial condition only is not enough, by itself, to define a body as such; any given body is necessarily extended, that is, it is subjected to the space condition (from here one can show the indefinite divisibility property of bodies; see below), but, contrary to what Descartes and other partisans of mechanistic physics have pretended, the extension does not constitute at all the whole nature or essence of bodies; the whole nature of bodies cannot be reduced to extension: to say that a body is nothing but extension in a purely quantitative sense is really the same as to say that its surface and its volume, which measure the portion of extension actually occupied by it, are the body itself with all its properties! Some of these properties (e.g., body’s size) are certainly taken from the spatial condition, as well as other determinations such as the situation of bodies in space. However, some

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25 There have been more sophisticated attempts to treat space (or space-time; see the appendix) as the primary concept from which the properties of bodies can be deduced (e.g., Misner et al. [1957]). These approaches in general take into account more qualitative aspects of space. It is, however, impossible to explain the corporeal world from the solely spacial condition.
other conditions are required to define a body, including time and the materia secunda mentioned in footnote 15, but this subject is out from the scope of this article.

In the same order of ideas, bodies are continuous because they are extended and participate in the nature of extension (property of space); and similarly, the continuity of movement (see Sec. 4), as well as the various phenomena more or less directly connected to it, derives essentially from its spatial character. Thus, the continuity of extension is ultimately the true foundation of all other continuity that is observed in corporeal nature. It is therefore extension (because of its continuous character) which gives the property of indefinite divisibility to bodies and other phenomena in the corporeal world. This does not mean however that there could not be discontinuity in the (corporeal) natural phenomena, in other words, “nature could make leaps”.

To complement these last ideas, in the following section we study the indefinite divisibility of extension or space (and that of bodies), its “smallest parts”, and “final elements”. Before that, we briefly mention that, from the previous considerations, one can distinguish two main positions in modern science, which can be explained by the over simplification entailed by the (almost) exclusive concern with the quantitative point of view. On the one hand, there are those who study some kind of space without bodies (like the geometric one) and apply, without any reserve, the obtained results to the physical space; on the other hand, we have those who, by analyzing only the measurements of corporeal phenomena (quantitative point of view), seek the nature of space. Regarding the departing points of these positions, it is clear that there will be some apparent coincidences between them, but we have seen how these “indications” or coincidences can be misleading, or, at least, insufficient as regard the understanding of the corporeal world. These positions are also present, in some way, in the case of time (see Sec. 3).

2.1 Divisibility of extension, its smallest parts and final elements.

Divisibility is a quality inherent in the continuous nature of extension26, its limitations can only come from this nature itself: as long as there is extension, it is always divisible, and one can thus consider its divisibility to be truly indefinite, its indefinitude being conditioned, moreover, by that of extension. Consequently, extension as such cannot be composed of indivisible elements, for these elements would have to be extensionless to be truly “indivisibles”, and a sum (a union) of elements with no extension can no more constitute an extension than a sum of zeros can constitute a number (different from zero).

26 A discrete space would amount to the existence of (multiple) empty regions which we have already ruled out.
This is why points, being indivisible, are by that very fact without extension (that is, spatially null) and therefore, they can in no way be considered as constituting an element or part of length\(^{27}\) (or of a line); in fact, the true linear elements are always distances between points, which latter are only their extremities: points are limits or extremities, not constituent elements of linear elements\(^{28}\). From here, it is obvious that points, multiplied by any quantity at all, can never produce length; the true elements of a magnitude

\(^{27}\) With respect to this last statement, "points can in no way be considered as constituting an element or part of length", the following objection has been addressed to us: there exists a branch of modern mathematics called "measure theory", which claims that a non-zero length, of a given interval of a line, can be obtained from a countable sum of points, provided that an appropriate notion of "measure" is defined. However, it is not without reason that this theory is sometimes called “abstract measure theory” (see e.g. Reed, 1992, Sec. I.4): in such a theory, one is able to define the “measure” of a point to be different from zero (a trivial example is given by the "Dirac measure" which, in particular, assigns the number 1 to a given point \(x\), and 0 otherwise)! From here, it is not surprising that one is able to obtain a non-zero length from a countable sum of points. Nevertheless, this “measure” has nothing to do with the realized space in the corporeal world (or even geometric space), space herein under consideration. Therefore, this objection is ill-defined within the considerations discussed in this work. Otherwise, if somebody would insist on establishing a relationship between this “measure” and the corporeal world, this would be equivalent to ask (in “naïve” terms): which is the ruler from which we would obtain a non-zero outcome when “measuring” a point?! (That is, a point with size.) This is actually a misleading question, because in reality a point cannot be measured: it escapes the spatial condition (as discussed in the main text). This takes us to the interesting question of the measure in the corporeal world. We cannot, however, pretend to study in detail this subject in the present work; we just mention the following. This measure is principally concerned with the domain of continuous quantity, that is to say, it is concerned most directly with things that have a spatial character (in this respect, see Sec. 3). This amounts to say that measure is specifically concerned either with extension itself, or with bodies (by reason of the character of extension they have). In the first case, the measure is more “geometrical”; in the second case, it would be more usually be called “physical” in the ordinary sense of the world. But, in reality, the second case leads back to the first, since it is only by virtue of the fact that bodies are situated in extension and occupy a certain defined part of it that they are directly measurable (but, recall, bodies cannot be only “spatial”), whereas their other properties are not susceptible of measurement, except to the degree that they can in some way be related to extension. Finally, it should be stressed that the definitions of “abstract measure theory” are based on “abstract” generalizations of this “intuitive” notion of measure and size; otherwise, why should one talk about “defining an extension [generalization] of size” for which, by the way, it is we who decide “what sets are to have a size” (see e.g. Reed, 1992, p. 14)!

\(^{28}\) A similar reasoning could be applied to curves with respect to surfaces and surfaces with respect to three dimensional space.
must always be of the same nature as the magnitude, although incomparably less: this leaves no room for “indivisibles” (or smallest parts), and it allows us to observe that ordinary quantities and infinitesimal quantities (in the sense of infinitesimal calculus) of various orders, although incomparable among themselves, are nonetheless magnitudes from the same species; that is, of the same nature of the “continuous” from which they arise. Thus, one cannot arrive at indivisible elements without departing from the special condition that is extension; the latter could not be resolved into such elements without ceasing to be an extension. It immediately follows that there cannot exist indivisible corporeal elements, without falling into contradiction. Indeed, these kinds of elements would have to be without extension, and then they would no longer be corporeal, since, by very definition, the word corporeal necessarily entails extension, although this is not the whole nature of bodies (see footnote 15).

We have then arrived at the following conclusion: the “continuous”, insofar as it exists as such, is always divisible, and consequently it could not have smallest parts. “Indivisibles” cannot even be said to be parts of that with respect to which they are indivisibles. If we would like, however, to talk about a “minimum”, one should understand it as a limit or extremity, not as an element: not only is a line less than any surface, it is not even a part of a surface, but merely a minimum or an extremity.

One should now be convinced of the impossibility of getting (within extension itself) an indivisible or smallest part of extension (or space). On the other hand, one could still ask about the “reality” of an “actual division” of extension or, in other words, the simultaneous existence of all the elements (or parts) of a given division of extension. This idea amounts to supposing an entirely realized indefinite and on that account is contrary to the very nature of indefinitude, which is always a possibility in the process of development,

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29 We could call these parts “final parts”, supposing that they are an “actual”, “effective” or “fundamental” division of extension.

30 The idea of indefinite is that of a development of possibilities, the limits of which, we cannot actually reach, that is, a development that in itself and in its whole course always consists of something unfinished. The indefinite implies a certain determination and limitation, this limitation and determination coming from the nature of the “object” under study itself. In this sense, the indefinite proceeds from the development of finite, a development extended until the limits are found to be out of our reach, at least insofar as we seek to reach them in a certain manner that we can call “analytical” (this does not mean, of course, that these limits might not be reached by others means). As an example, take the sequence of natural numbers:
hence essentially implying something unfinished, not yet completely realized. Moreover, there is in fact no reason to make such a supposition, for when presented with a continuous set we are given the whole, not the parts into which it can be divided, and it is only we who conceive that it is possible to divide this whole into parts capable of being rendered smaller and smaller so as to become less than any given magnitude, provided the division be carried far enough; in fact, it is consequently we who realize the parts, to the extent that we effectuate the division. Thus, what exempts us from having to suppose an “actual division” of extension is the following: a continuous set is not the result of the parts into which it is divisible but is on the contrary independent of them, and, consequently, the fact that it is given to us as a whole by no means implies the actual existence of those parts. In this respect, any given body (as any continuous set) constitutes a whole, logically anterior to its parts and independent of them. All continuity, when taken with respect to its elements, embraces a certain indefinitude. In this sense, these elements have a “conventional” character, that is, it is we who give a reality to the elements or parts as such, by an ideal or effective division. In this respect, consider the following example. The “number” 2 regarded, not as an arithmetic quantity, but as the

here, it is obviously never possible to “stop” at a determined point, since after every number there is always another that can be obtained by adding a unit; this sequence is formed by successive additions of the unit itself, indefinitely repeated, which is basically only the indefinite extension of the process of formation for any arithmetical sum. Here one can see quite clearly how the indefinite is formed starting from the finite (the sequence of natural numbers constitutes a multitude, formed from the unit, that surpasses all numbers), and how the indefinite is a development that in itself and in its whole course always consists of something unfinished, something analytically inexhaustible. It is worth mentioning that here we understand “analysis” in opposition to “synthesis”. The analysis implies the separation of a whole into its component parts, and a process in development. All synthesis is instead something immediate, so to speak, something that is not preceded by any analysis and is entirely independent of it; it is “synthetic” knowledge which lets grasp principles. In this sense, contrary to the current opinion, according to which analysis is as it were a preparation for synthesis and leading to it, so much so that one must always begin with analysis, even when one does not intend to stop there, the truth is that one can never actually arrive at synthesis through analysis. (But more detailed considerations about this would take us quite far from the purpose of the present work.) It is in this sense that the limits of the indefinite can never be reached through any analytical procedure, or, in other words, that the indefinite, while not absolutely and in every way inexhaustible, is at least analytically inexhaustible.

31 There are no indivisible corporeal elements, or “atoms” in the sense given by some ancient Greek philosophers, or by some Hinduist and Buddhist schools which, by the way, were regarded as more or less heterodox at this respect. In the same sense, there are not indivisible fractions that cannot yield ever smaller fractions in the numerical order, or, in the geometric order, linear elements that cannot be divided into ever smaller elements.
geometric magnitude consisting of two units distance from a point arbitrarily chosen to play the role of origin. This magnitude can be conceived of, as it is well known, as the sum of a geometric progression, \(1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \cdots\); however, each addend or summand is of the same nature as 2, all of them are continuous magnitudes (segments marked off by lengths 1, \(\frac{1}{2}\), \(\frac{1}{4}\), etc.), as little they may be, and even if they decrease indefinitely. It is worth mentioning that 2, taken in this way (“geometrically”), is a continuous set constituting a “true whole” in the sense that it is logically anterior to its parts and independent of them.

When representing the “number” 2 as the “sum” of an indefinite multitude of “addends”, we have arbitrarily divided it into parts, which does not imply in any way the previous and effective existence of these parts; here, it is we who give a reality to the parts as such. On the other hand and in an inverse sense, when taking the number 2 arithmetically (as a discontinuous quantity), it does not constitute a true whole, since it is the simple sum of its parts (two times the number 1, the arithmetic unit), and which consequently is logically posterior to them; as such, it is nothing other than a “being of reason or of the mind”: it is “one” and “whole” in the measure that we conceive it as such.

In other words, by itself, the number 2, conceived arithmetically, is strictly speaking only a “collection”, and it is we who, by the manner in which we envisage it, confer upon it in a certain relative sense the character of unity and totality.

We have particulary extended these ideas because, nowadays, there are some theories in modern physics (increasingly disseminated) which try to give a “fundamental” character to the so called “ultimate” (or “smallest”) parts of “matter”, better know as “elementary particles” (e.g. [Redhead, 1980]; here, “ultimate” or “smallest” is understood in an “effective” way, meaning that there is no actual way for modern physics to go beyond this “fundamental structure of matter”. At a smaller extent, some other theories focus on the “ultimate” (or “smallest”) parts of space. But, these parts cannot have any

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32 This concept differs of course from that one used in physics in a non “quantic” sense, for example in Newtonian and relativistic mechanics. In the latter, a “particle” consists of a body whose dimensions are so small, compared to the distance involved in its movement, that they can be ignored when studying its movement. This is an example of the “idealizations” discussed in Sec. 3.1.

33 Most of the theories going in this direction are the so called “quantum theories of space-time” or some interpretations of “quantum gravity” (e.g. [Rovelli, 2004, 2006]). By the way, according to some of the interpretations of these theories, there is a “fundamental” determinate space length; for example, Planck length, \(l_P = 1.6 \times 10^{-35}\) m, is considered by [Rovelli (2007), p. 1289] as a possible “minimal length”, as a measure of the “granularity” of space. For us, as we have seen, this has at most a conventional character, not a “fundamental” one. Furthermore, since these theories treat time and space jointly, the discretization of time is also entailed in these theories (see Sec. 3). The scope of these kinds of theories is indirectly treated in Secs. 3.1 and 5 and the appendix.
real “fundamental” character; on the contrary, they have, at the most, a conventional character: it is we who, for any given reason, give some importance to these parts. For example, they may be useful, to a given extent, to describe or “represent” at some level the corporeal world. But they are not, we insist, “fundamentals”; they are only “pieces” (portions) of the same nature as the whole (as bodies or extension), which we decide to study analytically, namely, by dividing the whole into parts.

In this respect, we believe that there are not solid arguments leading to claim that these kinds of theories are penetrating to the essence (the nature) of bodies and/or space. (Recall what we have said about quality and quantity in the introduction.) One could say instead that they may be getting into a more detailed “analysis” of the whole under study, which does not imply however that they are getting into something more essential or “fundamental”: the parts of a “continuous” (or any “true whole”) are of the same nature (of the same species) as the “continuous” itself; the “continuous” or any chosen part of it, because of its very nature of divisibility, is analytically inexhaustible.

3 Time

We consider time ("physical" time) as the container of events, and everything that has been said about the correlation of container and content with respect to space and bodies, and its consequences, could be repeated with respect to time and events. However, the nature of time is much more difficult

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34 In the same order of ideas, see Secs. 3.1 and 5, and the appendix.
35 In the sense explained in footnote 30.
36 Some words have to be said about the word “event”. The notion of “event” with respect to time is analogous to that of body with respect to space; just as this one extends in space, an event is a happening extended in time (it has a duration: an event always lasts some time). With regard to time, as we shall see, an event must be understood in its notion of development, that is, how the event unrolls. An event in this sense should not be confused with that one used, for example, in a more restrictive and technical way, in some areas of modern physics (notably in the theory of relativity), where an event is defined as a given point of “space-time” (without spatial extension nor time duration). For us, the temporal equivalent of the geometrical point is an instant, that is, something that has not duration at all: instants conceived of as indivisibles are no more parts of duration than are points of extension. Instants can in no way be considered as constituting an element or part of duration; instants are limits or extremities of a duration. In this respect, one has to always keep in mind that an event has a (temporal) duration and that there can no longer be any succession within an instant. All this is not in contradiction, as in the case of space (see footnote 28), with the idea that the instant can be seen as the origin of time.
to grasp: space can be measured directly; time, instead, can only be measured by relating it back to movement, thus, we can say, to space. Evidently, as any continuous magnitude, we measure a duration (or time interval) by using an arbitrarily chosen interval as time pattern. However, the “unit” of time (or pattern) requires for its conception the notion of movement, and, therefore, that of space. It should be clear that the direct inaccessibility of time through measurements does not imply, in any sense, that time does not exist or that we may reduce its nature to that of space. In this respect, there are some people (scientists and philosophers alike) who believe that they have to get around time by considering evolution of bodies with respect to themselves, that is, the description of the changes (in general) of some given bodies with respect to the changes of some other bodies. This may be, to some extent, a nice idea when trying to describe (or “represent”) evolution of bodies in the corporeal world. However, this does not permit us to say that we are getting around time, or that time does not exist at all, or that we are penetrating the nature of time. This would be like a geometer believing that he is exploring

37 It is in this sense that the earth’s daily motion was used to define the “unit” of time. Presently, the “unit” of time consists of taking a certain number of periods of electromagnetic field’s oscillations associated with the radiation emitted by a Cesium isotope in a given atomic transition.

38 We could go even further by claiming that we never measure a duration, but the space covered throughout this duration in the course of a movement for which the law is known; and as any such law expresses a relation between time and space, it is possible, when the amount of the traveled space is known, to deduce therefrom the amount of the time taken to travel the given distance; and whatever may be the artifices employed, there is actually no other way than this whereby temporal magnitudes can be determined. To seriously consider this affirmation, we would require a more detailed study on the nature of movement, which will not be undertaken in the present work.

39 In the same order of ideas, time is not the only magnitude that must be related back to space in order to be measured; in fact, almost any property of bodies, in order to be measured, should be related back to space (to the extension). This means that these properties can only be indirectly measured through space. Again, this does not mean that these properties are essentially spatial. This signifies instead that they can only manifest themselves, in one way or the other, through space (as time does through movement).

40 This approach is nowadays sometime called “relational evolution”. By the way, we wonder how the evolution of one single body is described in these terms.

41 At least one of these presumptions is explicitly stated in all of the so-called “timeless” physics theories; but, in general, when one says “timeless” in this context, one means more particular and technical things (see e.g. Barboult, 2000; Rovelli, 2004, 2006). To give an example: one is said to have a “timeless” theory when one manages to get rid of a parameter which was, somewhat conventionally, called “time”. Even so, it would be difficult to deny that time (as we explained here) is still there! One of the authors has closely followed theses kind of theories (see e.g. Hellmann et al., 2007).
the nature of (geometrical) space when doing geometry; the reality is that space and figures are presupposed by him. In the same sense, we wonder if, by doing modern science, which considers exclusively the phenomena happening in the corporeal world, we can access the nature of space and time; the corporeal world is already a result of the combination of space and time (and other conditions; see footnote 15). We would like to insist on the fact that we do not deny the possible usefulness of these procedures (such as “relational evolution”, or “general relativity” and all its possible extensions). However, we contest the pretention that, from these procedures, one would like to extract the nature of time. What we have said about the over simplification of space could be used in this case to support this statement. (All these considerations are considerably extended in the appendix).

Space and time present another resemblance. It is evident that periods of time are qualitatively differentiated by the events unfolded within them, just as the parts of space are differentiated by the bodies they contain; it is not, therefore, in any way justifiable to regard as being really equivalent durations of time that are quantitatively equal when they are filled by totally different sequences of events. However, the symmetry between space and time in this respect is also not perfect, because the situation of a body in space can vary through the occurrence of movement, whereas that of an event in time is rigidly determinate and strictly “unique” (in the sequence of events) so that the essential nature of events seems to be much more rigidly tied to time than that of bodies is to space! This implies that in a sequence of events there is a succession, an ordered development or evolution. We will call temporal succession the succession of events ordered on time; in other words, to the order followed by the content of time. There is still another remarkable difference between space and time, namely, the absence in the case of time of a quantitative science of an order comparable to that of the geometry of space (this should not be confused with the geometrical representation of time which is treated in what follows).

The considerations bring forth so far will help us to study some ideas about time.

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42 See Sec. 3.1 for a little discussion about that.
43 In philosophy, in particular, the Scholastic philosophers, the term “duration” has been used to characterize all possible modes of succession, that is, in short, any condition that could correspond analogically to what time is in the corporeal world. In this sense, time is a particularization of “duration”; time is only a mode, among many others, of duration. In scholastic terms, in this work, we are dealing with “tempus” and not with “aevum”, a more general mode of duration.
44 We could define a succession of positions (on space) of a given body; however, as we have said, this succession could be modified by the effect of movement; it is therefore not as “fundamental” as the temporal succession.
**Empty time.** The idea of an empty time, that is, a time without events (or even periods of time without events) is much less widespread than that of empty space (or holed space). This may be the case because time and events are more closely related than are space and bodies: events cannot be moved from one time to another (as bodies do through space by the action of movement). In any case, an empty time has no more effective existence than has an empty space, and in this connection everything that has been said about space could be repeated in some sense: time is coextensive, in the temporal sense, to events, just as space is with bodies; and realized time contains all events, just as realized space contains all bodies. Here, we find, therefore, another symmetry between space and time.

**Homogenous time.** A homogenous time can be conceived as something that unrolls itself uniformly. However, as we have already said, this cannot be the case since quantitatively equal portions of time are filled by totally different sequences of events.

**Geometric representation of time.** The tendency of looking for a geometrical (or “spatial”) representation of time may come from the difficulty (mentioned above) of separating time and space at a sensible level: in order to make measurements of durations one has to relate time back to space. In this respect, it is important to remark that there is no need of any particular geometrical representation for any of the considerations made so far. In modern physics there is a strong practice for representing time geometrically by a straight line. This representation comes from an over-simplification and from the idea that time is something which unrolls itself uniformly (a homogenous time). This representation may also come from an attempt to describe the unique situation of events on time; however, a straight line is not the only possibility (think about a helicoidal representation, for example). Some more sophisticated representations of time have been considered with the advent of “space-time” in modern physics. We refer the reader to the appendix for considerations about the notion of “space-time”.

**Continuity of time.** A crucial consequence of considering a “discrete time” is the existence of “intervals” devoid of the temporal condition, which is impossible within the corporeal world, according to our previous discussions. Indeed, this supposition would imply the hypothesis of a constantly renovated

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45 In relation to that, it would be interesting to study the representation (not necessarily geometrical) of time by cycles which has developed in some cultures. This conception takes into account a cycle as representing a developed “process”, taken in its most general sense.
“creation”; otherwise the world would always vanish away every instant during the intervals of temporal discontinuity. This strongly argues for the continuity of time. It must be continuous, just as space is. One could then again develop all that has been said about the divisibility of extension, namely, there cannot be indivisible time durations or smallest time durations nor “final” time durations: instants conceived of as indivisible are no more parts of duration than are points of extension (see footnote 36); and “final” (in the sense given in Sec. 2) durations are contrary to the very nature of indefinitude (cf. footnote 30). Following the same ideas, events (as the analogs of bodies) participate from the duration of time (a one dimensional continuum); there cannot then exist indivisible events.

These considerations strongly argue against the usual conceptions of “time’s atomicity”: in terms of Kragh et al. (1994) “any time interval consists of a finite number of indivisible, but extended and equal parts; the parts may also be unextended so long as they are equally spaced by a finite amount.” (p. 438).” Modern physicists have developed some considerations (mainly influenced by quantum physics) about the “atomicity or discontinuity of time”; but, as it is well summarized by Kragh et al. (1994) they (the physicists) are not interested in whether “atomistic time” is logically consistent or philosophically meaningful, but whether or not it is of any use as an instrument of physics (modern theories of physics, we would specify). This points very much in the sense of the discussion we undertake in the appendix.

To end this section, we would like to offer some considerations about the repeatability of events and statistics that are very much related to the qualitative aspects of time.

3.1 Repeatability of events and statistics

Nowadays, both in daily life and science in general, there is an increasing use of, and an ever growing importance is attached to, the notion of repeatability of events (or phenomena), statistics, and probability. We think it is worth saying some words about this, since it is directly related to what we have said about events and some qualitative aspects of time.

In modern science, a basic assumption and requirement is that one can re-

46 Remember that extension, being continuous, has the inherent quality of divisibility.
47 Their historical review offers a good overview of the physicists’ concerns about time “discreteness”. Many of the considerations there presented have not lost their topicality.
repeat the same (“identical”) experiments as many times as one wants. This assumption is sometimes called the “principle” of repeatability of identical events or phenomena and no inquiry is made about. We believe that this “principle” has more to do with the inductive aspect of the scientific method than with a true principle; it has to do, in fact, with the empirical and statistical character of modern science. In any case, this “principle”, by using the “principle of indiscernibles”, is something inconceivable. Moreover, the impossibility of having identical events automatically prevents us from accepting the widespread assertion that the same causes always produce the same effects, since the happening of the “same causes” (or “same effects”) implies the repeatability of events. Indeed, one should say instead that *causes that are comparable one to another in certain aspects produce effects similarly comparable in the same aspects*. But, as it is often forgotten, alongside the resemblances, which can, if desired, be held to represent a kind of partial identity, *there are always and inevitably differences*, because of the simple fact that there are, by hypothesis, two distinct things in question and not one single thing. In this respect, one has to be careful, because in some cases a superficial and incomplete observation might give the impression of a sort of identity; but actually differences can never be eliminated. Even if there were no differences left other than those arising from the ever-changing influence of time and place, they could still never by entirely negligible, because, as we have seen in detail, space and time cannot be, contrary to some conceptions in physics, merely homogenous containers. On the contrary, temporal and spatial determinations have also in reality a qualitative aspect that will not be considered in the present work. However that may be, it is legitimate to ask how, by neglecting differences, as if we refuse to see them, we can still possibly claim that our sciences are “exact”. In reality, modern science (except for pure mathematics) is not much more than a series of approximations which are more or less suitable for some experimental or practical purposes, or particular facts, which is what this science is really interested in. This is not only true from the point of view of the application of science, in which everyone is forced to recognize the inevitable imperfection of the means of observation and measurement, but even from a purely theoretical point of view as well: theoretical modern science resorts very often to over “idealized” models and suppositions that make one wonder about their real relationship with the sit-

48 In this sense, it is enough to remember the concept of statistical ensemble in science in general and in statistical physics and quantum theory in particular.

49 By this principle one has to understand that there cannot exist anywhere two identical beings, that is to say, two beings alike in every respect: it can be said that if two beings are assumed to be identical in this sense, they would not really be two, but, as coinciding in every respect, they would be actually but one and the same being! In order that beings may not be identical or indiscernible there must always be some qualitative difference. This principle carries with it the absence of any repetition in particular possibilities.
uation under consideration; in that respect, some representative examples in theoretical physics are a “massive material point” or an “unstretchable and weightless thread” or a “free falling body” or even a “perfectly isolated system”. In more recent modern physics such suppositions have become more “exotic”: there are “identical particles”, “auto-interactions”, and so on.

The idea of founding science more or less on the notion of repetition (in the approximate sense described before) creates an illusion, the one consisting in thinking that the accumulation of a large number of facts can be used by itself as “proof” of a theory. Nevertheless, it is evident that facts of the same kind (meaning that they are comparable only in certain aspects) are always indefinite in multitude, so that they can never all be taken into account, quite apart from the consideration that the same facts usually fit several different theories equally well. It will be said that the establishment of a greater number of facts does at least give more “probability” to the theory; but to say so is to admit that any certitude cannot be reached in that way, and that therefore the formulated conclusions have nothing “exact” about them; it is also an admission of the totally empirical (and inductive) character of modern science.

This takes us to the consideration of statistics. Statistics really consists only in the counting up of a greater or lesser number of facts (events) that are supposed to be exactly alike (if they were not so their addition would be meaningless). It is evident that the picture thus obtained represents a deformation of truth (or of “reality”), and the less the facts taken into account are alike or

50 The “idealizing technique” and its origins are complex and interesting subjects. It is interesting to see for example how the “idealization” as understood nowadays has its roots in the Renaissance. We have for example that (McMullin, 1985) “When Galileo was faced with complex real-world situations... he shifted the focus to a simpler analog of the original problem, one that lent itself more easily to solution. This might, in turn, then lead to a solution of the original complex problem... Idealization in the ‘Galilean style’ soon became a defining characteristic of the new science.” (pp. 254-255). Galileo defended these idealizations by arguing that “the departure from truth is imperceptibly small.” (p. 256)” (it is this pretension of getting a “solution” from such “idealizations” which we have mainly criticized in this work, not the possible practical usefulness of “idealizations”). But, “A physics that borrows its principles from mathematics is thus inevitably incomplete as physics, because it has left aside the qualitative richness of Nature.” (p. 249).” Here, it might be of interest for some to point out that, in the last citation, mathematics should be understood, in our opinion, in its (most commonly known) quantitative sense, and not, as understood by the Pythagoreans for example, in all its qualitative extent.

51 See footnote 30.

52 This is the case whenever we want to have a theory with some kind of generality. Otherwise, “scientific theories” become nothing else but models describing a given number of particular facts.
really comparable, or the greater the relative importance and complexity of
the qualitative elements involved, the worse is the deformation. Spreading out
numbers and calculations gives a kind of illusion of “exactitude”; but in fact,
without this being noticed and because of the strength of preconceived ideas,
very divergent conclusions are drawn indifferently from such numbers (in the
sense of figures), so completely without significance are they in themselves.
The proof of this is that the same statistics in the hands of several experts,
even though they all may be “specialists” in the same area, often give rise,
according to their respective theories, to quite different conclusions, which
may even sometimes be diametrically opposed. In these conditions, the sci-
ences that we called “exact”, to the extent that they make use of statistics
and go so far as to extract from them predictions for the future (relying always
on the supposed identicality of the facts taken into account, whether they are
in the future or the past), have, to a great extent, a “conjectural” character,
as many scientists have been forced to admit. Currently, the tendency is to
change the vocabulary from “exact theories” to “rigorous theories”, meaning
that such theories are checked against experiments, or that these theories are
the result of linking up somehow a series of experimental facts, but we think
we have already said enough to hint at the scope of these kinds of theories.

4 Movement and its relationship with space and time

In this section we consider only some elementary aspects of movement that
are directly related to the two previous sections, that is, to space and time.
Even though space and time are the necessary conditions of movement, this
does not mean, however, that they are the first cause of movement! In this
sense, one could say that in the manifestation (“expression”) of movement
there is a combination of space and time. In a given movement, the amount of
traveled space, being the sum (union) of a series of elementary displacements
regarded in successive mode (that is, precisely under the temporal condition),
is a function of the time spent to cover it; the relation that exists between
this space and this time expresses the movement law under consideration.
From here one can obtain what is currently know as the speed formula which,
taken for each instant (that is, for infinitesimal variations of time and space),

53 The history of modern science offers many examples illustrating this assertion.
Moreover, almost any modern scientist knows that this kind of debate is part of
daily-working research life. In particular, a glance at the history of evolutionary
(evolutionism) thought offers a nice example in this sense.
54 Another use of the term “rigorous theory”, which we shall not treat here, is that
one stating that this theory is “mathematically consistent”.
55 In the sense that a variable quantity depends on another one.
is represented by the derivative of space with respect to time. Moreover, it is from movement, as we have seen, that time is rendered measurable by relating it back to space. Of course, we can consider the inverse problem and express time as a function of space, “just” by inverting the relation considered previously, but this is not the point we want to emphasize.

As we have pointed out, movement is manifested as a combination of space and time. This sort of combination would not be possible if one (time or space) were discontinuous and the other continuous. This reinforces what has been said about the continuity of space and time. Conversely, we have argued that both space and time must be continuous, whence we can conclude that the movement must be continuous, and, even more, “doubly continuous”. Movement embraces then an indefinitude of successive positions, which is different from considering each of these positions in isolation, that is, as we have seen, it is different from regarding the points, lines, and surfaces as fixed and determined, and as constituting the parts or elements of the line, the surface, or the volume, respectively.

We close this little section by pointing out that bodies are the “seat” of movement. Indeed, in the corporeal existence, because of the effect of the combination of spatial and temporal conditions, everything is in movement; as a consequence, it is materially impossible to draw effectively a curve in space which is truly closed. For example, if we want to draw a circumference beginning in a given point of space, due to our movement, at the end of the drawing we will necessarily end up in a different from that of departure; we will never come back again to the departure point.

5 Conclusions and perspectives

In this work we have developed to some extent the idea of (“physical” or realized) space as the container of bodies, and (“physical” or realized) time as the container of events. In particular, we have focused on the “philosophical” consequences this idea could have in some conceptual aspects of modern physics. In particular, we have addressed the ideas of an empty space, portions of empty space, a homogenous space, smallest (indivisible) parts of space (or of a body), and “final” elements of space (or of a body), which we have proved all to be erroneous (or at most conventional) within the conceptual framework here exposed. Those characteristics which have been shown to be

\[56\] This rate can be constant or variable depending on whether the movement is uniform or not.

\[57\] In these respects, the Zeno of Elea’s arguments offer a proof of the continuity of movement.
erroneous are then not applicable to space as a condition of the corporeal world. With regard to time and events, similar conclusions have been drawn; we have shown however that between time and space there exist rather big qualitative differences, which make time’s nature much more difficult to grasp than that of space. We have also treated to some extent the impossibility of repetition of events and some of its implications in modern science. We have finally considered some basic aspects of movement and its relationship to time and space.

We would like to minimize possible misunderstandings by situating this work with respect to the three main philosophical positions listed in the introduction:

In this respect, we can claim that the ideas exposed in the present manuscript do not enter into any of those positions, mainly because the considerations here made do not properly belong to any philosophical system. We could summarize our “position” about space and time as follows: space and time are not independent of “things” (bodies and events), but they are not a consequence of them either; they hold instead a container-content correlation with them, in such a way that the corporeal world has space and time as manifesting conditions. Of course, this does not prevent us from considering space and time as distinct from “things”.

Continuing at the philosophical level, it is interesting to see how, from the ideas presented in this work, one can “half”-solve one of the antinomies of Kant: the world had a beginning in time, and is also limited as regards space; or the world had no beginning, and has no limits in space, but it is infinite as regards both time (eternal) and space. From the point of view described in this article, it is the coextension of space and time with the world which permits us to assert that there cannot be more space than there is world (and vice versa, as it is generally accepted), and, similarly, that time has begun with the world and the world with time.

To answer the last part of this antinomy, namely, “the world is infinite as regards both time and space”, some more considerations would have to be developed. Within our perspective neither space nor time (and, therefore, nor the world) can be “infinite”; what we can say at most is that they extend “indefinitely”. However, we cannot give a satisfactory explanation to this point by the means given so far. In this sense, it would be interesting to deal, in some other works, with the question of “infinity”. That work should begin by clarifying the meaning of “infinity”, “eternal”, and some related concepts.

For further works it would also be interesting to explore the following points:

- How the “speed” with which events are unfolded depends on time and on its situation in time. We mean that one should study the possibility that
sequences of events comparable one to another do not occupy quantitatively equal durations and how this “speed” behaves along time.

- So far, we have discussed the correlation of space and bodies, time and events, and a little has been said about the relation of time and space. However, nothing has been said about the “interaction” (or mutual action-reaction) between space and bodies, and time and events; as well as the possible “interactions” time-space, space-events, time-bodies, and so on. We are mainly interested in the qualitative and conceptual aspects of the issue, though some quantitative aspects could be addressed.

- It would be of some interest to study some more quantitative aspects of currently established physics theories within the conceptual framework given in this article. This has to be with a mathematical approach to the ideas treated in this work. One could see, for example, to what extent conservative quantities are suitable for “physical” space and “physical” time as presented here. On could also interpret, from the present point of view, some known experimental facts. In this way, one is going from the ideas to particular facts, and not, as it is now usually done in science, in agreement with its inductive-empiric method, from particular facts to “general theories”.

- Finally, another very interesting point would be to study in detail the relationship between the point and the space. One could see, for example, how the latter has its origins in the former.

To close this conclusion, we would like to formulate some comments about the critical observations we have levelled at some aspects of science, and some criticisms that may be addressed to this work.

We have illustrated, through some examples, how modern physics turns to conventional terminology and “idealizations” which cannot penetrate the nature of space and time in particular, and the corporeal world in general. This causes the clear impression that physics theories, to a great extent, are not much more than a “representation” or description of corporeal nature, of outward appearances, lacking in that same extent of an explanatory value. It may also be observed that the theories, which go farthest in the direction of a reduction to the quantitative, are generally “atomistic” in one way or another, that is to say that they introduce discontinuity into their notion of “matter” in such a way as to bring it into much closer relation to the nature of number than that of extension. A clear example of this is offered by the most recent theories of “space-time”; see e.g. Butterfield et al. (2000); Monk (1997); Rovelli (2007, 2004, 2006). Does not this point in the direction of bringing everything down to quantity instead of quality, thus moving away from the “essence” of things (as explained in the introduction)?

58In any case, the representation of a thing must not be confused with the thing itself.
Clearly, as we have already mentioned several times, we do not discredit the usefulness (mainly in “practical life”) or the descriptive capacity of modern science and its theories. We would like rather to bring up the fact that science, as it is conceived presently, has very little chance of offering somewhat deep explanations. A detailed discussion on this point and related subjects could give rise to a work on the “methods, scope and limits of modern science.”

In this respect, it is true that we have not offered either a complete explanation of space’s and time’s nature. However, we think we placed ourselves on a not very common (in modern times) point of view, the main interest of which is to take into account the qualitative aspects of the object under study. In other words, we have studied some “fundamental” aspects of space and time, which are closer to quality than to quantity (recall what we have said about quality and quantity in the introduction). From such point of view, it is possible to deduce some consequences for modern science that do not always coincide with generally accepted notions (in modern science). Modern science, on the contrary, takes almost exclusively the empirical and practical perspective, plus the analytic method. Its point of departure is the mechanistic and materialistic conceptions, together with an almost exclusively quantitative point of view, entailing, necessarily, a lack of interest in the deep sense of things, i.e. in their principles, in one word; in “synthetic” knowledge (we recall what we have said in footnote 30). Most modern scientists thus content themselves by measuring some properties (those with a more direct quantitative character) of the object under study, or by finding a possible “practical” application for them, disregarding, in this way, the true meaning of the concepts they are using.

Finally, we would like to say, to those who may regard this work as a useless dialectic, that these considerations may be useless for many purposes, but definitely not for trying to understand the world we live in; and we would add that these considerations should be better regarded as cosmological, in the sense that the scope of the cosmological order includes the corporeal world, and in general the “manifested world.” This constitutes part of science in its extended sense, i.e., science supported in the principles. In other words, reasoning supported in intuitive reason (or intellect) or scientific knowledge supported in metaphysical knowledge. As is clearly explained by Aristotle

59 On the other hand, because some of these theories make so many unrealizable suppositions (or “idealizations”), we wonder to what extent they are really describing the world we live in.

60 “Manifested world” should be understood as the resultant of the action exercised by the Natura naturans on the Natura naturata, or, equivalently, the action of Purusha on Prakriti (in Sanskrit) from Hindu doctrines. Taken in their extended sense, we could say that the manifested world results from the “union” of the “essence” and “substance” or, in the Aristotelian terms, ἐσθος and ἴλη.
(Posterior Analytics, 100b 5 – 100b 17):

"... no [thinking] state is superior to science except intuitive reason; the first principles are more knowable than the conclusions from them, and all science involves the drawing of conclusions. It follows that it is not science that grasps the first principles; and that it must be intuitive reason that does so. This follows also from the fact that demonstration cannot be the source of demonstration, and therefore science cannot be the source of science; if, then, intuitive reason is the only necessarily true state other than science, it must be the source of science. It apprehends the first principle, and science as a whole grasps the whole subject of study; i.e. science as a whole grasps its object with the same certainty with which intuitive reason grasps the first principles.” (see Ross, 2001, pp. 675 and 678).

And St. Thomas of Aquin (De Veritate, q. XV, a. 1):

"Ratio discursum quemdam designat, quo ex uno in aliud cognoscendum anima humana pervenit; intellectus vero simplicem et absolutam cognitionem (sine aliquo motu vel discursu, statim in prima et subita acceptione) designare videtur." (See, e.g., Aquinatis, 1953, p. 307).” [The reason refers to a given discursive process through which the human soul reaches the knowledge of one thing by using another one; the intellect refers to the simple and absolute truth’s knowledge (which is obtained immediately, without any movement nor any discursive process, in a first and sudden grasping).]

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A  Space-time

In this appendix we deal with a concept that may be of interest to many physicists, the notion of “space-time”. This section is rather technical, it is mainly addressed to people having at least some notions on the theories known as “Special relativity” and “General relativity”. In particular, we permit ourselves to use the jargon of these theories. Evidently, the reading of this appendix is not required to understand the main text. However, the consider-
ations at the end of the section might be of general interest, since we study some of the ideas about space-time in the context offered by this article.

After the Middle Ages, the concepts of space and time suffered some important modifications. As almost everything during that epoch, previous concepts of, and ideas about, space and time were taken almost only in their quantitative and empirical sense, denuding them from almost all their qualitative aspects. In physics, some of the most influential ideas about space and time are those coming from Isaac Newton by the end of 17th century. These ideas are still very present in many fields of science. This success is attributed to the empirical verification that Newton’s theory had and still has in its domain of application. Moreover, this can be regarded as the reason why the relational point of view from Gottfried Wilhelm Leibnitz (described in the introduction) was nearly buried for more than 200 years.

As we have already mentioned in the introduction, Newton conceived of space and time as absolutes: space is a limitless, homogenous, container through which objects can freely move and remains unaffected by the presence of objects in it; time flows with perfect uniformity forever and nothing affects its flow. In addition, space and time could be empty (empty containers) and still have sense within the corporeal world. Geometrically speaking, space was thought of as a homogenous, isotropic, unlimited, and three-dimensional continuum; and time as a homogenous, unlimited, one-dimensional, and uniformly flowing continuum (usually represented by a straight line\(^\text{61}\)). Nothing, in modern physics, prevents us from regarding this space and this time as a fusion of space and time forming a single entity that we could call Newtonian space-time. In this “space-time”, simultaneity could be defined with respect to absolute time: to each instant (a point in the linear time) it corresponds to a (three-dimensional) space; all events (if any) happening in that space are simultaneous to that instant. Duration, distance and situation are also determinate with respect to this absolute space-time. For most practical scientific applications, Newton’s model of space and time is quite convenient. However, this model breaks down for some aspects studied by physics\(^\text{62}\) and some other models of space and time were sought.

The idea of fusing together space and time is generally attributed to Hermann Minkowski who, at the beginning of the 20th century, claimed that space and time should be conceived always together, space and time became space-time (the points of this four-dimensional entity were called events, see footnote\(^\text{36}\)). This space-time is now called Minkowski space-time. But, if this fusion can be

\(^{61}\) Usually this time is denoted mathematically by a real variable \(t\) or, in the context of the theory of relativity (see below), by an imaginary variable \(it\) (as was used for some time).

\(^{62}\) For example, this model breaks down for speeds near the speed of light and strong gravitational fields.
already done for Newtonian space and time, as we have seen, why has space-time then become so relevant for physicists? Its main differences with respect to Newtonian “space-time”, as Einstein (1954, Ch. *The theory of special relativity*) explains, are that time gets entangled with space (time and space follow a common transformation—from one observer to another—law, *Lorentz transformations*) and simultaneity at different spatially separated points becomes dependent of the observer’s movement. Apart from these facts, Minkowski’s space-time strongly resembles Newtonian “space-time” (as we have seen, the latter can be conceived jointly, as space-time, or separately, as space and time). We have, for example, that Minkowski’s space-time (as the Newtonian) is a presupposed structure, fixed once and for all; it is not affected by objects (including clocks and rods) and their movement. Minkowski space-time is the new world’s scenario: if one takes away objects, empty space-time remains.

The theory of “special relativity” was also born at this period (in 1905, 3 years before the conception of Minkowski space-time). The notions of (measured) duration and (measured) distance in this theory become observer dependent, they are relative to the observer’s velocity. The observers, for which Newton’s first law is valid (*inertial observers*), have a “privileged” place in the theory. Indeed, these observers are those which define Minkowski space-time and *Lorentz* reference frames. What’s more, the relativity “principle” tells us that the laws of physics should be identical in any such frame. It is also found that these observers move uniformly relative to one another. On the other hand, this theory posits that light propagation occurs with the same velocity for all inertial observers. The invariance of the speed of light becomes then another crucial ingredient of special relativity; light is the fastest signal for one observer to communicate with another. We have, therefore, that in the theory of special relativity, the concepts of space and time come along with these “observational” and empirical notions. For “relativists”, the laws of nature are meaningful only if they relate things that can actually be observed (in the sense of a quantitative “measurement”). In this sense, for “relativists”, time and space do not exist anymore only as “abstract” concepts; they made them more “concrete” by referring them to observers and quantitative measurements.

Many usual geometrical ideas were extended to Minkowski space-time (four dimensional “entity”) and special relativity. For example, the idea of “distance” between space-time points (or “events”; see footnote 36) was defined. This spatio-temporal “distance” has the “funny” property of accepting negative or null values for separate “events” under some circumstances. This idea has become attractive to many physicists because, unlike ordinary distances and duration, this “distance” is invariant, that is, it does not depend on ob-

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63 Pauli (1967), for example, offers some nice accounts of both the theory of special relativity and general relativity.
servers (at least those defined by the theory). Many take this as an indication of the intimate relation between space and time.

Albert Einstein sought then to generalize “his” special relativity. After quite lengthy considerations, he reached the (general) equivalence “principle” that states, in its strongest form, that “in any and every local Lorentz frame (inertial frame of reference), anywhere and anytime in the universe (except for singularities), all the laws of physics must take on their special-relativistic forms”; or, more precisely, “there is no way, by experiments confined to infinitesimal small regions of space-time, to distinguish one local Lorentz frame in one region of space-time from any other local Lorentz frame in the same or any other region.” Distances and durations (measuring of) depend now on the position of “clocks” and “rods” in a gravitational field. These general ideas resulted in the “mechanical” and mathematical formulation of one “theory of gravitation”, better known as “general relativity”. One of the main features of this theory is “general covariance” which pleases a geometric, coordinate-independent and no-prior-geometry formulation of physical laws. However, we shall not enter into the complicated considerations of this formulation. We just mention that, as a consequence of this formulation, the geometry of space-time might not be Minkowskian in presence of a gravitational field, since the latter curves space-time. The resulting geometry is called pseudo-Riemannian. From here, one is able to conclude that the presence of massive bodies (as the source of gravity) must curve space-time; in other terms, space-time is not fixed once and for all (as in special relativity), it reacts to the presence of massive bodies and gravity. Therefore, massive bodies (and energy), gravity, and space-time must follow a dynamical law. The discovery of such a law is also attributed to Einstein.

General relativity is considered by some physicists the “mechanical” realization of Leibnitz’s and Ernst Mach’s relational ideas. These physicists classify the notions of space-time given so far as “invisible” or “abstract” concepts

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64 Gravitational field is usually attributed to massive objects. In fact, any kind of energy produces and undergoes gravitational effects, because, according to a result of special relativity, the energy is equivalent to some quantity of mass.
65 A “Prior geometry” is any aspect of the geometry of space-time that remains unchanged by changing the distribution of gravitating sources. Newtonian and Minkowski space-time are examples of prior geometries.
66 As it is spelled out by Misner et al. 1973 “Space acts on matter, telling it how to move. In turn, matter reacts back on space, telling it how to curve.” (p. 5).
67 Some other (complicated and unclear) pictures of space-time taking into account also notions of quantum theory can be found, for example, in the nice review by Monk 1997. (See also Butterfield et al., 1999, 2000).
68 Some recent publications about this are offered by Rovelli (2004, 2006) and Barbour (2000). Dicks (2006) and Monk (1997) also review different “theoretical” approaches to the “disappearance” of space-time.
and aver instead that all that exists are objects and their relative motions. For them, general relativity should not be at all about these “abstract” concepts of space and time: it should be only about physical devices called “clocks” and “rods” and their related features. In other words, they believe to circumvent the ontological problem of space and time by considering space and time as nothing more than rules that govern how things are ordered and how they change; for them, all that exists are things that change, and space, time and motion are defined through the relations among objects. Concretely, they take general relativity, together with the supposition (or similar ones) that space-time and the gravitational field (or its configurations) are identical or interchangeable, as the realization of these (“relational”) ideas. Before general relativity, they say, there was always a distinction between the stage (space and time or space-time) and actors (bodies, fields, etc.), as in a play in a theater; with general relativity instead, space-time becomes an actor (the gravitational field) and the stage has no more reason to exist. From here, they follow the abolition of space and time: all that exists are things that change and things over things (“matter over matter”). Indeed (they explain), space and time (or space-time) in general relativity are mixed up with the gravitational field and “matter”; therefore, they conclude, the concepts of space and time are from now on no longer needed, all we need to “understand” the world are the gravitational field and “matter”; therefore, the “mystery” of space and time is reduced to a semantic (conventional) problem. This is why they claim (and diffuse all around) the “end of space and time” or the “non-existence of space and time” at a “fundamental” (analytical) level, but always within the corporeal world (this is an essential point for the criticisms developed below), telling us at the same time that these theories are a (big) “revolution”. However, when they so assert, they really mean that these concepts (as conceived by themselves or their direct predecessors) will cease to have an essential role in the foundations of modern theories of physics. 69 We shall offer some more considerations about this in what follows.

All this is very much in accordance with the empirical and inductive attitude that modern scientists have been developing for centuries. They believe that, since something is out of reach of the experiments (or their theories), this same thing necessarily does not exist or, in a “better” case, they consider that it might exist, but that it is out of the reach of human understanding. There are still some other scientists who, in spite of recognizing (at least in some sense) the limitations of modern science, wonder how they could go beyond these limits if modern science is the most wonderful “creation” of the human mind and its greatest achievement!

As we have argued in this work, space and time are instead essential con-

69 One of the authors has had the opportunity to closely follow the development of these ideas (see e.g. Hellmann et al., 2007).
ditions for the corporeal world. Space and time (together with some other conditions; see footnote 15) make this world what it is and not something else. When regarded with respect to the corporeal world, space and time are correlated (in the sense explained in the main text) to it and we cannot study them independently of it. It must be now clear that this does not imply that one cannot, absolutely and in every way, study the nature of space and time in themselves; but, when doing so, the obtained results have to be carefully brought back to the study of the corporeal world as it is.

In this sense, we believe that physicists claiming the disappearance of space and time at a “fundamental” level confuse two very different things. They confuse space and time with the consequences of their action. They take the corporeal world (with all its phenomena, objects, etc.) as the point of departure, and from its analysis (in the sense explained in footnote 30) they want to conclude that space and time “do not exist”, meaning in reality that these conditions are not needed at a “fundamental” level by the corporeal world or by modern theories (which are supposed to at least describe the corporeal world). However, we repeat, space and time are two essential conditions for the corporeal world: this world is what it is thanks (in part) to space and time. In this respect, we would like to briefly explain an analogy which, even from its very conception, reflects many aspects of the considerations developed and the conclusions drawn by these physicists. The analogy is the following: it would be like taking a plant by itself (if it were possible) as point of departure, and from its analysis, we would like to draw the conclusion that light and substratum are not necessary conditions for the plant in question. Light and a substratum are two essential conditions (the seed being a third one) for the plant’s sprouting and development, they determine the existence of the plant, and this is true for all levels of analysis of the plant taken by itself. The description or study of the plant can be done, within some limits, without even knowing of the plant’s need for light and substratum; but, in this simple case, who would dare to deny the need (or the existence) of such conditions, without which the plant could not even exist? Light and substratum are essential for the plant, they make (in part) the plant be what it is and not something else or something different! This simple example illustrates our impression of the considerations reviewed above that end up denying the need (or the existence) of space and time for the corporeal world from its analysis. In this respect, we believe that space and time are much more than ad hoc “abstract” concepts (as they would like to claim). This might be the case for the quantitative (almost denuded of any qualitative aspect) space and time conceptions in modern physics, but this is radically different from declaring the “needlessness”, at any desired level, of space and time for the corporeal world. We think that the knitting of things in the corporeal world foxes them in some way: they believe being delivered from space and time in scrutinizing the corporeal world, but in reality they are studying some consequence of the action of space and time.
We close this section by briefly looking at the theories described above (Newtonian mechanics, and special and general relativity) from the point of view offered in this article. In this respect, we would like to say that it is quite difficult to get a general and coherent picture of the ever-changing scientific theories. We have tried, however, to outline what seems to be the most elaborate picture about theories concerning space and time (besides, perhaps, thermodynamics). In general, these theories, as they are, can be seen as an effort to describe (not to deeply explain) the corporeal world. In particular, we think that we have already said enough in the main text in order to realize that most of the Newtonian space and time aspects are misleading. The common interesting point of special and general relativity is that they deal, at least in some sense, with the relationship between space and time. General relativity, in addition, is regarded, at least in its conceptual foundations, as an effort to treat in a unified way space, time, their respective content and, to some extent, their mutual interactions. As such, in that respect, these theories would deserve more attention, especially in what we could call their qualitative (if any) aspects. However, this would demand a rather detailed and meticulous study of these theories (especially, by far, of general relativity). In this respect, the present work lacks, to a great extent, considerations regarding the relations between space and time and their interaction (that is, their mutual action and reaction). Almost nothing has been said either about the interaction between space and bodies, time and events, etc. This would demand much more complicated considerations, which would take us quite far from the actual scope of this work. We hope, however, to be able to give some insights about them in the future.

At another level of considerations, we believe that the need of some physicists to “spatialize” or “geometrize” time comes from the relationship, at quantitative level, of space and time: when measuring a time duration one has to relate it back to space (see Sec. 3). From this requirement and the transformation law relating space-and-time coordinates in special relativity, it is not difficult to get to the idea of a “space-time geometry” and things of the sort briefly outlined in this appendix. But, is this “geometrization” necessary to understand the nature of time? How far can we push ahead this “geometrization” without moving away from time’s essence? In this respect, there is still another interesting subject that we do not treat in the present work: it is about the possibility, under some very special conditions, of a “real” (literal) spatialization of time.

On the other hand, what we can say with complete certainty is that the gravitational field, being already part of the corporeal world, cannot simply be identified with space and/or time. As we already explained, a scientist

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70 The historical account written by Redhead (1980) offers an example, in modern physics, of this statement.
working with relativity (as almost any modern scientist, by the way) can at most aspire to get a more or less precise representation of the effects produced by space and time, notably of the bodies’ movement and the development of events. In particular, they could get, above all, a quantitative description of the space and time features susceptible of being reduced to figures. At this point, it should be clear that we do not question the phenomena observed by physicists, since these are not more than facts. What is doubtful for us are some of the conclusions they draw from them.

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