Patrice F. Dassonville

The Invention of Time and Space

Origins, Definitions, Nature, Properties

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Foreword

What Patrice Dassonville proposes in this book is an exhilarating ride through our changing notions of space and time since human thoughts were first recorded, with an in-depth mastery of the related historical, philosophical, scientific, and technical aspects. Viewed as a whole, this fascinating and intriguing discussion throws light on both general issues and detailed questions, and in a nutshell shows that time and space do not exist by themselves, but are instead purely intellectual constructions of humankind, built up through a lengthy process extending roughly over the last 5000 years of human history.

The first four chapters provide introductory material outlining the main difficulties involved in a true and genuine definition of the concept of time and/or duration. (As a matter of fact, exactly the same problem occurs with space and/or distance). Also discussed are the so-called arrow of time and ancillary issues such as synchronicity and temporality.

Chapter 1 is an introduction presenting the basic aims and objectives of the book and discussing the contents. It outlines the difference between a discovery which relates to a phenomenon (or to reality), and an invention which is connected to a concept.

Chapter 2 concentrates on the main issues of the discussion, by introducing the use of dialectics. It emphasizes the lack of definitions, and also the unknown nature of time and space and their unidentified properties.

Chapter 3 digs deeper into these issues, which are related to the failure of dialectics. It outlines the confusion between time and event, and describes the semantic disorder concerning the duration of the ongoing (or present) time, countless metaphors, aphorisms, sophisms, truisms, and so forth, including artifacts (i.e., conceptions based on an idea, such as a clock or a clepsydra, used to evaluate the duration between two events).

Chapter 4 is then devoted to the use of models (mathematical tools) in order to describe reality with the help of the concepts of time and space, for instance, enabling one to predict events such as astronomical occurrences. Evidently, because mathematical modeling is simply an invention of human intelligence, it carries

artifacts and approximations to the studied reality. Physical laws are obtained accordingly by mathematical models applied to the observation of nature. On the philosophical side, these laws evolve over time (or through history)—they are relative (and not absolute), and can be modified later on, depending on new observations or new models of nature.

The chapter ends with a classic example drawn from small deviations to Kepler's first law describing the movement of the earth around the sun as an elliptical orbit. Due to the presence of the moon, it is no longer a two-body problem, and the trajectory is modified to a sinusoidal converging spiral ellipse.

It is worth noting, the very large number of references to Greek, Roman, and modern Western philosophers in these four introductory chapters. These provide complementary points of view on the central issues relating to time and space.

Chapter 5 describes historical perspectives of the origin of time through history with the help of iconographic sources taken from various ancient civilisations, including the Maya, Ancient Egypt, Ancient China, the Roman empire, African and eastern European people and tribes, and so on. It outlines the obvious evidence of time and duration derived from the alternation of day and night, cyclic events due to seasons, and the lunar month or monthly cycles of the moon. This anthropological approach introduces the division of the day into hours (12 h for half a day, a number that can be divided by 2, 3, 4, and 6), minutes, and ultimately seconds (with 60 min in 1 h and 60 s in 1 min, again a number that can be divided by 2, 3, and 4, but also 5, 6, and 10). This constitutes a convenient arrangement for dividing and organizing everyday life.

In the second part of his book, the author investigates more detailed ideas for describing the nature of time and space, to explain temporality and spatiality. Chapter 6 focuses on the definition and nature of time. The second was originally obtained from an ethnocentric and anthropo-centric view of the rotation of the earth, since it is defined as 1/240th of a degree. A more technical definition was finally given in the 1960s, exploiting the oscillations of atomic transitions in cesium (atomic clocks), but it still relates to the original definition, and this implies regular adjustment of the reference time because the rotation of earth is slowing down slightly as time goes by (during rotation cycles). This is due to friction within the atmosphere, which in turn is responsible for many meteorological effects such as the trade winds and tropical hurricanes, because of the Coriolis force.

The non-phenomenology of time is accordingly well established. Time proceeds as a reference variable in physics, always in the denominator of total or partial derivatives. This in turn indicates that the physical variable under study (i.e., distance, temperature, pressure, density, electric charge, energy, or any other physical quantity) is simply derived versus time (or duration between two events). The absolute definition of time is consequently not satisfactory, as clearly outlined and demonstrated by the author, because it is referred to the delays between two events, which are compared to the earth rotation phenomenon. Radioisotope dating techniques, such as those developed by Willard F. Libby, based on the half-life of the C_{14} isotope, or thermoluminescence decay, can be used to date post-mortem organic remains or old pottery. Dendrochronology can also be used for dating,

studying the alternating clear and dark rings in the cross section of a tree trunk. As stressed by the author, these are simple artifacts related to the alternation of the seasons, and are not linked to time, which still remains undefined.

Patrice Dassonville then puts forward a general definition of time, as "a concept corresponding to what separates two states of a system". He then examines the etiology of aging, distinguishing between biological and chronological age. The physical inexistence of time is linked to the fact that time has no source. The author then ends the chapter with some examples taken from different areas of theoretical physics, such as general relativity and quantum physics, to show how time is difficult to manipulate, and difficult to define rigorously.

The following four chapters move on to other issues, using several different approaches. Chapter 7 deals with the definition and nature of space, where the problems are quite similar, yet different. Somehow, one can see space by the objects which are present within it, and we all have an intuitive understanding of spatiality. From a physical point of view, there is a major difference between physical space and empty space. The basic conceptualization of space occurred with reference to our own movements, e.g., the concept of one day-walking distance (approximately 25–30 km), which reappears in the context of the light year (approximately 9.45 10^{12} km).

The meter was defined according to an international convention as one ten-millionth part of a quarter of the earth meridian, before a more sophisticated definition was introduced, viz., the distance travelled by light during 1/299 792 458th of a second. Obviously, since this number is related to the speed of light, it teaches us nothing: distance is defined through time, which is circular. A more precise definition can be obtained by going back to the conceptual issue of "physical space being the concept of what separates two systems". Accordingly, spatiality in empty space is not guaranteed. Furthermore, empty space is simply a limiting concept which never actually exists, because there will generally be waves and ripples everywhere.

Chapter 8 attempts to describe the link between space and time mathematically in the framework of the space-time formalism. They are related through the Poincare–Einstein transformation laws of special relativity, or through the associated Riemann space-time invariant interval of the theory of general relativity, which takes into account the gravity of massive objects such as stars or black holes. In such cases, the definition of time (or space) becomes even more abstract, being a mathematical concept, where time and space are modified by the speed of the object under study, or by gravity acting on it.

The author ends the chapter by describing a number of well-known experiments, highlighting certain paradoxical features. None of these examples will convince the reader that time and space are anything other than pure concepts, the invention of human beings to explain and master the surrounding world, including the most remote and massive objects within the universe. In such cases, some of the theoretical tools developed by astrophysicists such as Stephen Hawking actually introduce the time parameter as a complex quantity, yet another step toward the conceptualization of time.

The last two chapters are more philosophically oriented. In Chap. 9, Patrice Dassonville provides an historical overview of time and space. Starting from the written precursors or traces of these basic concepts, the author tries to build up a progressive conceptualization of time and space, through repetitive series of events (or spatial occurrences), to the most sophisticated interpretation of time and space. Ernst Mach considered that time and space do not exist by themselves, but are simply convenient parameters for formulating physical equations. It may be that research will one day propose models that get rid of space as well as time, in a new physics and a new description of the universe.

Chapter 10 puts forward some ideas based on just such a new description of the world, where time and space can be replaced by other descriptors. The author starts by explaining what time and space are and what they are not. He then moves on to the characteristics of "the physical properties of systems", which in turn imply the "mathematical properties of time and space". He investigates the causal link, well known and documented in the physical sciences, between a cause and the observed effects, showing that in many circumstances, e.g., in quantum physics where time is stochastic (i.e., probabilistic), there does not exist a formal link between cause and effect. The Big Bang cannot set the fundamental reference time to zero, because there is no particular reason to do so. Relativity and quantum physics have broken the hold we once had on time and space, because of the intricacies in the associated mathematical modeling. At the end of his life, Einstein himself was thinking about a new physics where time and space would be totally removed from theoretical models.

The book ends with a short summary and conclusion in Chap. 11, and a glossary bringing together many words and expressions relating to time and space (Chap. 12). Here the author opens some new directions for research. The concept of time is generally speaking, in the common sense, poorly and arbitrarily introduced, and usually remains ill-defined.

The author's experience in his past work as a scientist and engineer working in many fields and many different locations, including the USA, France, and Africa, qualify him for this in-depth discussion of the concept of time and its use in everyday life and potential applications. The book is well written and properly documented, with many intriguing and original examples and discussions. It should interest scholars and scientists, as well as the general public. It could be read as a complement to other sources, such as the well-known book *A brief history of time* by Stephen Hawking, which was written with the aim of explaining the cosmos and cosmology, gravitation and black holes, the expansion of the universe, the big bang and time, to a wide audience, but otherwise contains no simple and rigorous description of time and space.

Patrice Dassonville's book goes back to some very basic and natural ideas and concepts. Time lies at the very heart of our everyday lives. Time and space will long remain a puzzle, not only for those trained in the physical sciences, but also for others, including poets and ordinary people looking out into the cosmos. There, within the relevant mathematical models, time is simply connected to space through the speed of light, the Minkowski–Einstein transformation laws, and the theory

of general relativity. The existence of gravitational waves, discovered by an international team at the beginning of 2016, just in time for the 100th anniversary of their theoretical prediction by Albert Einstein in one of his seminal papers, constitutes a major breakthrough for science and technology at the onset of the twenty-first century.

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