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Space and Time
(Underlying philosophical Distinctions)

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ABSTRACT:
We are acquainted with references to space and time, as if we are dealing phenomena of the same kind. Yet we shall argue that juxta-posing space and time amounts to nothing van comparing apples and oranges. In general time is often associated with the flow or duration. Yet as soon as we consider something like time-measurement it appears that time takes on different shapes. Stafleu points out that time measurement initially simply boiled down to *counting* (days, months, years, etc.). Then time was measured by the relative *spatial position* of the sun or the stars in the sky (with or without the help of instruments like the sundial). Subsequently time was measured by utilizing the *regular motion* of more or less complicated clockworks. More recently time is measured on the basis of irreversible processes, for example, in atomic clocks. But time is not merely one aspect of reality – it is an ontic dimension of the universe in its own right which comes to expression within every modal aspect of reality in accordance with the unique meaning of such an aspect. Space belongs to the dimension of modal aspects, alongside others such as the numerical aspect, the kinematic aspect, the physical aspect, the biotic aspect, and so on. As a modal-functional aspect of reality space co-conditions the existence of all kinds (classes) of entities. Its *modal universality* implies that all classes of entities function within the spatial aspect. The relative position of the aspect of space among other modal aspects will be analysed in this article. It will be argued that time is neither merely physical in nature nor solely to be identified with any other specific modal aspect. All modal aspects and entities are embedded in the ontic dimension of time – and the aspect of space is just one of the multiple modal functions of the universe. Therefore, it is not correct simply to position space and time next to each other for then apples and oranges are compared. More specific issues and questions addressed in our analysis are: the infinitely large and small; does nature make jumps?; wat is entailed in the switch from Kant to non-Euclidean geometry; how do we have to account for different kinds of space – such as physical space, biotic space, sensory space, or logical space?; are analogical terms inevitable; do we live in a space-time continuum?; why is perceptual space non-Euclidean?

In everyday parlance it is customary to combine references to space or time with time or space. If you ask an American or a Canadian how far it is from point A to point B – a *distance* question – you often get a *time* answer: 5 hours. In our everyday experience space is not understood in an abstract mathematical sense, but rather in a concrete physical way. But even when this avenue is pursued, the intersection between time and space soon surfaces. Just think about the standard practice in astronomy to speak about distance in terms of the time it takes for light to travel to get to a celestial object. In his work on infinity A.W. Moore reminds us of the Andromeda nebula. On a clear dark evening a dim spot of light marks the constellation Andromeda. This galaxy consists of about hundred thousand million stars. And each one of them is a sun similar to our own. Moore points out that its light "needs about two million years to reach us and that it is the farthest object visible to the naked eye. Yet by comparison with other galaxies it is a close neighbour" (Moore 1990:xi). And during the past three decades we witnessed the incredible capacities of the Hubble telescope.

1. THE INFINITELY LARGE AND SMALL

Although the notion of infinity ultimately makes an appeal to the succession of natural numbers, it was *space* that opened the way for an appreciation of the infinitely small, as it became known via the infinite divisibility of something continuous (Diels-Kranz, Zeno B. Fragments 3 & 4 and Anaxagoras B. Fragment 8). Aristotle actually contemplated both the infinitely large and the infinitely small: "Further, everything that is infinite may be so in respect of addition or division or both" (*Phys*. 204 a 8-9; Aristotle 2001 260). He claims that the general statement holds: "Moreover, it is plain that everything continuous is divisible into divisibles that are infinitely divisible" (Phys. 231 b 1-2; Aristotle 2001:317). In his work on the foundations of mathematics Ludwig Fischer still continues this legacy when he writes: between two non-coinciding points we always have "continuum," referring to the fundamental law: "continuum-point-continuum" (cf. Fischer 1933:86-87).

Aristotle holds that things are in succession "if there is nothing of their own kind intermediate between them, whereas that which is intermediate between points is always a line and that which is intermediate between moments is always a period of time" (*Physic*. 231 b 6-10; Aristotle 316). He also argues the "continuous nature of both time and magnitude. For the "divisions of which time and magnitude respectively are susceptible are the same and equal" (*Phys*. 232 a 23; Aristotle 2001:318). To this Aristotle adds that "things being 'continuous' if their extrèmities are one" (*Phys*. 231 a 2-3; Aristotle 2001:316) and also holds that "it is impossible for anything continuous to be composed of indivisible parts" (*Phys*. 232 a 23-24; Aristotle 2001:318).

2. DOES NATURE MAKE JUMPS?

This idea of *divisibility* raises the question whether or not there are "indivisibles"? This question immediately reminds us of an ancient idea proposed by the Greek atomists, Leucippus and Democritus, namely that there are last indivisible particles of matter. Nonetheless the discovery of "incommensurable quantities" by 450 B.C. caused Greek mathematics to revert to the idea of continuity, that is, to use *space* as fundamental principle of explanation of nature, eventually captured by Leibniz in the slogan that nature does make jumps (*natura non facit saltus*). Descartes illustrates the long-standing nature of this view by holding that space (extension) is the characteristic property of his *res extensa* (*extended* substance) – distinct from the thinking substance (*res cogitans*). In his *Meditation VI* Descartes distinguishes between the indivisible soul and the divisible body (Descartes 1965:139).

But he rejects the idea that there are "any atoms or parts of matter that are of their own nature indivisible" (Descartes 1965:209). Simply by being extended such parts will always be further divisible.

> And even is we "suppose that God had reduced any particle of matter to a smallness so extreme that it did not admit of being further divided, it would nevertheless be improperly styled indivisible, for though God had rendered the particle so small that it was not in the power of any creature to divide it, he could not however deprive himself of the ability to do so, since it is absolutely impossible for him to lessen his own omnipotence, as was before observed. Wherefore, absolutely speaking, the smallest extended particle is always divisible, since it is such of its very nature" (Descartes 1965:209).

3. SUBATOMIC PARTICLES

The continuity postulate of Leibniz ruled the day until modern physics about a century ago reverted to smallest indivisible material units, apart from the fact that even the assumed continuity of light waves turned out to also allow for the discreteness of light quanta, namely photons.

More than 100 years ago, in 1911, Rutherford's atomic theory proposed that atoms are constituted by an electrically positive nucleus and negatively charged particles moving around it (a view imitating the planetary system). Niels Bohr then designed a new theory assuming first of all that electrons move only in a limited number of discrete orbits around the nucleus and in the second place that they move from a high energy orbit to one with a low energy content, causing electromagnetic radiation. The atom displays an integrated functioning in which the multiple sub-atomic particles are united. It is remarkable that the size of the nucleus of an atom, multiplied by 100,000, gives the distance between the nucleus of an atom and its (circling) electrons.

The matter of an atom is concentrated in a volume of less than a 0.00000000000000000001 part of the volume of the atom – which amounts to saying that atoms are more than 99.9999999999999999999% empty (19 zeros before the one – Kiontke 2006:27 – see also Penrose 2005:645 ff.). According to wave mechanics the electron of a hydrogen atom (in its lowest orbit) moves around the nucleus at a speed of about 6.8 million km per hour (Kiontke, 2006:27).

4. FROM KANT TO NON-EUCLIDEAN GEOMETRY

Relativizing the geometry of Euclid occurred more than 100 years ago, when Lobachevsky and Bolyai questioned the axiom of parallels in Euclid's geometry. Kant still explains his understanding of space in Euclidean terms and transposes both space and time into *a priori* forms of intuition. This constitutes one stem of knowledge for him with the table of categories of understanding, which are *logical* in nature, as the other stem. In the transcendental aesthetic Kant pursues the aim to isolate sensibility (*Sinnlichkeit*) by subtracting whatever understanding with its concepts can think such that nothing but empirical intuition remains (Kant 1787-B:35). In the transcendental logic and its subdivision, the transcendental analytic, Kant leaves empirical concepts aside such that the pure concepts do not belong to intuition and sensibility but to thinking and to the understanding. Pure understanding separates itself not only from everything empirical but also from sensibility. It is a self-sufficient unity (Kant 1787-B:89). This created an unbridgeable gap between understanding and sensibility.

5. SENSORY SPACE

Von Bertalanffy remarks that Kant viewed the forms of intuition as a priori and immutable. However, for the biologist, who finds no absolute space or time because the experience of the perceiving organism depends upon its organization, there is no absolute space or time since they depend on the organization of the perceiving organism. The time-honoured appreciation of three-dimensional Euclidean space as the a priori space of experience should therefore be challenged, perception is not Euclidean.

In perceptual space there is an important difference between top and bottom, right and left, and fore and aft. The effect of gravity causes an inequality of the horizontal and vertical dimensions. Von Bertalanffy in addition points out that we experience it as quite correct that parallels such as railroad tracks, converge in the distance.

> Exactly the same perspective foreshortening is, however, experienced as being wrong if it appears in the vertical dimension. If a picture was taken with the camera tilted, we obtain "falling lines," the edges of a house, e.g., running together. This is, perspectively, just as correct as are the converging railroad tracks; nevertheless, the latter perspective is experienced as being correct, while the converging edges of a house are experienced as wrong; the explanation being that the human organism is such as to have an ambient with considerable horizontal, but negligible vertical extension (Von Bertalanffy 1973:242).

Clearly there is a fundamental difference between *sensory space* and space in its original mathematical sense. Consider for example, the sensitivity of our skin for distinct sensations, such as the prick of a needle. While these stimuli may be distinct in a physical sense, in terms of feeling (skin-sensitivity) they may be experienced as continuous. Therefore, what in a sensitive sense is continuous could be, in a physical sense, discontinuous (see Gosztonyi 1976-I:13).

Look for a moment at physical extension and spatial extension.

6. ANALOGICAL TERMS ARE INEVITABLE

Our intuition of spatial relationships reveals another side of the coherence between different aspects or *modes* of reality. A mode or modality points at a way of existence, such as the spatial, physical and sensitive modes referred to above. One can designate the coherence between two aspects as *analogies* between them. An analogy is encountered when two aspects (or entities) are similar in that respect in which they differ. Dependent upon the order relation between two aspects such analogies may be labelled backward-pointing or forward-pointing analogies, or they may be characterized as retrocipations or anticipations.

The configuration of *physical space* reveals a retrocipation from the physical aspect to the spatial aspect. Similarly, sensitive space represents a retrocipatory spatial analogy within the sensitive mode. Moreover, we can also reflect on the way in which the spatial aspect points backward (retrocipates) to the quantitative aspect that serves as the foundation of the spatial aspect. Bear in mind that there is a difference between the order side and the factual side correlated with the order side within aspects. Within the spatial aspect one can discern a strict correlation between a one-dimensional order of extension and a factually extended spatial subject – in this case a straight line. One or more spatial dimensions presuppose the original numerical meaning of integers such as 1, 2, and 3. Dimension appears to be a numerical analogy on the order side (law side) of the spatial aspect, whereas factually extended spatial subjects are measured by using numbers – *length* in one dimension, *surface* in two dimensions and *volume* in three dimensions. The numbers specified as 1, 2, or 3 do not stand on their own because they appear within a non-numerical context. One can also phrases it as follows: we can speak about 1-dimensional extension (magnitude; that is, of *length*), 2-dimensional extension (magnitude; that is, of *area*), 3-dimensional extension (magnitude; that is, of *volume*), and so on.

The crucial question here is what a *magnitude* really is? Aristotle distinguishes between a discrete quantity and a continuous quantity (*Categories* 4 b 20; Aristotle 2001:14). But this distinction does not realize that quantity or *magnitude* analogically reflects the foundational coherence between number and space. A one-dimensional magnitude (quantity) is *distance*. But distance presupposes spatial extension, such as a one-dimensional line. It could be specified by a number, which is the *measure* of its extension, but it is incorrect to speak of a continuous or a discrete magnitude, because strictly speaking about any magnitude merely embodies (as measure of extension) the number attached to something extended. And the quantities assigned to different magnitudes may vary in accordance with the dimensional contexts in which they are specified. Acknowledging different dimensions is indeed something spatial, for no one can deny that somehow number here plays a foundational role, for without number, it would be impossible to have magnitudes in different (i.e., 1, 2, or 3) dimensions.

One facet of this foundational philosophical problem is given in the unavoidability of employing *analogical terms*, that is, in the use of terms reflecting the interconnection between different aspects. This follows from the fact that different modal aspects are interrelated in such a way that each of them, within its own structure, reflects the modal meaning of others. In our just-given example physical extension shows some likeness with spatial extension. Note that this way of addressing the issues implicitly highlights the problem of similarities and differences. If we look as physical extension and mathematical extension it is immediately clear that the element of *extension* is found in both expressions. The physical aspect and the spatial aspect are similar in the sense that we may discern *being extended* in both.

However, in *extension* as the element of similarity the *difference* is simultaneously revealed. In what sense are they different? First of all since the beginning of the 20th century physicists realized that the slogan that nature does not make jumps does not hold because, as we noted earlier, matter is not infinitely divisible and therefore not continuous. Already in 1925 David Hilbert has mentioned this difference (see Hilbert 1925:164). Bernays also distinguishes between physical space and mathematical space: "Only through the contemporary development of geometry and physics did it become necessary to distinguish between space as something physical and space as an ideal multiplicity determined by spatial laws" (Bernays 1976:37).

7. DO WE LIVE IN A "SPACE-TIME CONTINUUM"?

We are accustomed to mathematicians and physicists speaking of the space-time continuum in which we live. What they have in mind is Einstein's theory of relativity where time is added as fourth dimension to physical space. Of course, one can revert to an aspectual mathematical description of processes involving energy (with reference to a continuous variable), but then the concreteness of physical entities is left behind while taking recourse to a functional mathematical notion – in which case it is indeed meaningful to hold that such a continuous variable entails infinite divisibility. Maddy implicitly alludes to this distinction when she remarks that our best description of space-time is not establishing the continuity of space-time since the microstructure of space-time remains an open question. She holds that there is enough doubt about "the existence of any physical phenomenon that are literally continuous" (Maddy 2005:152). On the next page she adds to this observation "that a space-time continuum is not something we can take as established." So, strictly speaking, the popular conception of a space-time continuum is misplaced for it denies the difference between mathematical and physical space.

Of course, the idea of a "space-time continuum," as we noted, derives from Einstein's theory of relativity where time is introduced as the fourth "dimension" (co-ordinate).

Designating spatial dimensions as diverse orders of extension acknowledges an apparently purely spatial notion. Yet we have argued that both the extension of a line and its one-dimensional order of extension unveils the foundational coherence between number and space.

8. IS TIME MERELY PHYSICAL IN NATURE?

When it comes to the question: what is time? natural scientists by and large still limit the notion of time to the physical aspect of reality. But is it not perhaps a distinct *aspect* of reality, alongside modes such as the numerical, spatial or kinematic facets? Another alternative option is to identify a unique dimension of reality, namely that of *ontic time*. The implication would be that instead of looking for a distinct aspect we may be investigating how ontic time expresses itself within each aspect of reality.

In his work on the foundations of physics Stafleu relates time measurement to the first four modal aspects. He argues that the historical development of time measurement is significant.

> Initially, time measurement was simply done by counting (days, months, years, etc.) Later on, time was measured by the relative position of the sun or the stars in the sky, with or without the help of instruments like the sundial. In still more advanced cultures, time was measured by utilizing the regular motion of more or less complicated clockworks. Finally, in recent developments time is measured via irreversible processes, for example, in atomic clocks (Stafleu 1980:16).

Although Kant localized time as an *a priori* (inner) form of intuition, he did reveal a broader understanding of time where he distinguishes in his *Kritik der Reinen Vernunft* three *modes* ("modi") of time, namely endurance, succession and simultaneity [Beharrlichkeit, Folge und Zugleichsein] (Kant 1787:219).

It is clear that in the development of time-measurement different aspects served as *modes of explanation*. In his *protophysics* of 1976 and 1989 Lorenzen distinguishes four units reflecting the four modes of explanation found in the history of time measurement, namely *mass*, *length*, *duration* and *charge*. This shows that the legacy of connecting time merely with duration, the kinematic mode of time) is in fact embedded in a much broader context, embracing multiple modes of explanation. These distinctions are indeed found among a number of prominent physicists as well. Heisenberg (1958), for example, accepts two universal constants (Einstein's postulate of the velocity of light and Planck's quantum of action). But he was looking for another universal constant, namely a universal *length*. According to him one must have at least three units, namely *length*, *time* and *mass* or alternatively *length*, *velocity* and *mass* – or even *length*, *velocity* and *energy*.

An analysis of the first four irreducible modal aspects of reality underscores the inevitability of *four units*. These four units of measurement indeed reflect the ontic existence of the four foundational aspects of reality, represented in the diagram below. It concerns *number* ('mass'), *space* ('length'), the *kinematic aspect* ('duration') and the *physical aspect* ('charge'). Weinert (1998) mentions even that usually physicists "distinguish fundamental constants from conventional units" – and he then lists the *kilogramme* (number), the *meter* (space), the *second* (the kinematic) and *temperature* (the physical).

	Lorenzen	Heisenberg (a)	Heisenberg (b)	Heisenberg (c)	Heisenberg (d)	Weinert
Physical	charge	quantum of action			energy	tempera- ture
Kinematical	duration	c (velocity of light)	time	velocity	velocity	second
Space	length		length	length	length	meter
Number	mass		mass	mass		kilogram

Whereas physical time is *homogeneous*, biotic time is *heterogeneous*. The older a living entity gets the quicker the process of ageing takes place. The general biotic time order is that of birth, growth, maturation, ageing and dying – correlated with the widely differing life-spans of individual living entities.

It is known that positivism believes that knowledge and truth are found in sensory perception. However, as soon as this maxim is tested with reference to *time* it turns out that an Achilles' heel of positivism is unmasked. Initially, in Greek culture, matter is described in *numerical* terms ("everything is number"), then in terms of *space* (the starting point of Greek space metaphysics and the medieval chain of being with God as *ipsum esse*), followed by employing *movement* as explanatory term (the classical mechanistic world view of the universe as *particles in motion*), and finally concluded with the acknowledgement of the characteristic *physical* nature of material things.

The key question is whether these aspectual terms could be observed in a sensory way. Can these terms be *weighed*, *touched*, *measured* or *smelled*? Just contemplate questions such as: *What is the colour of the numerical aspect*? *What does the spatial aspect taste like*? *What does the kinematic aspect feel like*? and *What does the physical aspect sound like*? In a similar fashion we may ask whether or not *time* can be observed by the senses – and if so, by which one(s)? Can we *touch* time? Can we *see* it? Can we *hear* it? Can we *smell* it? Every affirmative answer to these questions will be absurd, showing that these *functional terms* as well as what the term *time* refers to cannot be observed by the senses. The reason is that neither time nor the various aspects of reality are concrete things. It is not difficult to realize that aspectual terms refer to a dimension of reality that is different from that of concrete (natural and societal) entities and processes. These entities and processes function within all the aspects of our experiential universe.

Consequently, the first step positivism had to take in order to digest "sense data" theoretically, has already eliminated the restriction of reliable knowledge merely to *sense data*!

That time cannot be identified with any single aspect also follows from these considerations. It is perfectly meaningful to speak of *temporal reality*, but it does not make sense to characterize reality exlusively in terms of a single aspect (such as the mentioned Pythagorean conviction that *everything is number*, the materialistic belief that *everything* is physical, the historicist claim that *all of reality is historical*, or the postmodern view that *everything is interpretation*).

Traditional conceptions of time constantly identified time with merely one *aspect of time* – for example, when "true time" is seen as *physical*, *emotional duration* (Bergson), that it is *existential* in nature (where existence is understood in a *historical* sense – Heidegger), and so on. Dooyeweerd was the first philosopher who realized that time is a distinct dimension of the universe and that time expresses itself uniquely within each aspect (see Dooyeweerd 2017, Parts A & B, pp.1-109). As a legal scholar Dooyeweerd substantiated his rejection of the suppposedly merely physical nature of time with an extensive analysis of the way in which time expresses it self in all the other aspect of reality. It includes the intriguing configuration of the legal validity of a law with retroactive effect, apparently at odds with the assumed arrow of (physical) time.

9. MULTIPLE NOTIONS OF SPACE

A key feature of the idea of aspects as modes of being or modes of existence is that all classes of entities function within all modal aspects – either as subjects or as objects. Natural and societal entities function in a typical way within them because they are grouped into types merely holding for a limited class of entities. The conditions (law) for an atom is universal in the sense that it holds for all atoms, but this universality is specified because it holds for atoms only. Therefore, type laws *specify* entitary functioning within these aspects in a *typical* way.

Consider how the size and shape of different living entities specify their concrete function within the spatial modality. It deepens the inner coherence between the spatial and biotic aspect, captured in well-known expressions like bio-milieu and bio-sphere.

Interestingly, the initial Greek idea of the *apeiron* as principle of origin received a new form within the general theory of relativity of Einstein. As an effect of gravitation Einstein mentions "the curvature of light rays by the gravitational field of the sun" (Einstein 1985:104).

Owing to *curved space* a body moving along a straight line on a spherical surface will eventually return to its point of departure. Einstein considers a two-dimensional existence on a spherical surface in which case the universe of these creatures would be "the fact that the universe of these beings is finite and yet it has no limits" (Einstein 1985:109). The heading of this Chapter (XXXI) reads: "The possibility of a 'Finite' and yet 'Unbounded' Universe" (Einstein 1985:108).

The typical functioning of living entities within their environments received a peculiar designation in the holistic biology of Adolf Meyer. With the aid of extensive empirical information, he formulates the following "basic typological law":

> There is no group of existing organisms belonging to any taxonomical category of the Natural System, whose members possess all group characters in their most primitive or in their most progressive phases only. Rather are primitive, intermediate and progressive character phases thus combined with each other in each real member of a group that an organismic holism suited for living in any real existing ecological biotope results from it. Forms which possess all their morphological characters in their primitive or in their progressive phases only are neither living holisms nor suited for existence in ecological biotopes and are, therefore, but purely ideal constructions (Meyer 1964: 59-60).

An articulated systematic account of the original and analogical meanings of spatial terms directed our attention to address related issues, such as the uniqueness and mutual coherence between different aspects and the analogical concepts found in disciplines, revealing the inter-modal connections between various modal aspects of reality.

These ontic modalities turn out not to be merely functional conditions for concretely existing entities, since they also serve as *modes of explanation* within different, but mutually cohering, scientific universes of discourse. Through the inter-modal coherence between the spatial and other aspects, we are fully within our epistemic rights to employ (analogical) concepts of space in diverse disciplines. Although we have highlighted some of these analogical connections – such as *physical space*, *biotical space* (*bio-sphere*, *bio-milieu* and so on), and *sensitive space* (the content given by Jakob von Uexküll to his notion of 'Umwelt' – 1970 and 1970a) – there are still many others. We may mention a few unexplored contexts: *logical space* (Rudolph Carnap wrote a work in which he reduced space to so-called *formal space* – see Carnap 1922), *lingual space* (also encompassing theories regarding the *semantic domains* of words), *social space* (think about notions of social stratification and social distance as well as *social spheres*), and *jural space* (intricate questions regarding the *location* of a legal fact or jural *spheres of competence*).

10. CONCLUDING REMARK

Juxta-posing space and time as it is commonly done ultimately boils down to a comparison of apples and oranges. As a modal aspect of reality space serves as a functional-modal condition for the existence of all kinds (classes) of entities. Its modal universality implies that all classes of entities function within the spatial aspect. It was argued that time is neither merely physical in nature nor solely to be identified with any specific modal aspect. All modal aspects and entities are embedded in the ontic dimension of time – and the aspect of space is just one of the multiple modal functions of the universe.

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