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Leibniz, the Young Kant, and Boscovich on the Relationality of Space

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Leibniz's main thesis regarding the nature of space is that space is relational.[1] This means that space is not an independent object or existent in itself, but rather a set of relations between objects existing at the same time. The reality of space, therefore, is derived from objects and their relations. For Leibniz and his successors, this view of space was intimately connected with the understanding of the composite nature of material objects. The nature of the relation between space and matter was crucial to the conceptualization of both space and matter.

In this paper, I discuss Leibniz's account of relational space and examine its novel elaborations by two of his successors, namely, the young Immanuel Kant and the Croat natural philosopher Roger Boscovich. Kant's and Boscovich's studies of Leibniz's account lead them to original versions of the relational view of space. Thus, Leibniz's relational space proved to be a philosophically fruitful notion, as it yielded bold and intriguing attempts to decipher the nature of space and was a key part in innovative scientific ideas.

1. Leibniz's Account of Relational Space

Leibniz's main thesis regarding space is that it is relational. He defines space as a set of relations between things which exist at the same time. The following is a clear exposition of Leibniz's definition of space from his correspondence with Samuel Clarke:

> "As for my own opinion, I have said more than once, that I hold space to be something merely relative, as time is; that I hold it to be an order of coexistences, as

[1] In addition to the standard abbreviations for Gerhardt's (GP, GM) and the Academy's (A) editions of Leibniz's texts, I use the following abbreviations: AG = G. W. Leibniz: *Philosophical Essays*, transl. by Roger Ariew/Daniel Garber, Indianapolis 1989; H = Id.: *Theodicy*, transl. by E. M. Huggard/ed. by Austin Farrer, London 1951; L = Id.: *Philosophical Papers and Letters*, transl. by Leroy E. Loemker, Dordrecht ^{2}1969; LA = Id./Antoine Arnauld: *The Leibniz-Arnauld Correspondence*, transl. by Haydn T. Mason, Manchester 1967; LC = Id./Samuel Clarke: *The Leibniz-Clarke Correspondence*, ed. by Henry G. Alexander, Manchester 1956; PP = G. W. Leibniz: *Philosophical Writings*, ed. by George H. R. Parkinson, London 1973; W = *Kant's Critique of Pure Reason. Background Source Materials*, transl. and ed. by Eric Watkins, Cambridge 2009.

> time is an order of successions. For space denotes, in terms of possibility, an order of things which exist at the same time, considered as existing together, without enquiring into their manner of existing. And when many things are seen together, one perceives that order of things among themselves."[2]

Later in the correspondence, Leibniz provides an elucidation of his definition by means of an analogy with "genealogical space" or family connections:

> "[...] [space] can only be an ideal thing, containing a certain order, wherein the mind conceives the application of relations. In like manner, as the mind can fancy to itself an order made up of genealogical lines, whose bigness would consist only in the number of generations, wherein every person would have his place; and if to this one should add the fiction of a metempsychosis, and bring in the same human souls again, the persons in those lines might change place: he who was a father, or a grandfather, might become a son, or a grandson, etc. And yet those genealogical places, lines, and spaces, though they should express real truth, would only be ideal things."[3]

A family tree and its genealogical lines depend on the existence of certain persons and their connections. These persons, as family members, bear specific genealogical relations to one another and form a certain order among themselves. There is no "genealogical realm" over and above the family members and the relations they bear to one another, and one need not assume such a realm in which these ordered relations somehow inhere, for these relations hold independently of any such presumed realm. The place of a family member in the genealogical tree is determined by the relations she bears to other

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[2] "Leibniz's 3rd letter", § 4, LC, pp. 25–26. See also: "[…][space] is that order, which renders bodies capable of being situated, and by which they have a situation among themselves when they exist together" ("Leibniz's 4th letter", § 41, LC, p. 41); "[…] space is nothing but the order of existence of things possible at the same time" ("Letter to de Volder, 30 June 1704"; GP II, 269 / L, p. 536); "[…] space is the order of coexisting phenomena" ("Letter to Des Bosses, 16 June 1712"; GP II, 450 / L, p. 604); "[…] just as in time we conceive nothing but the very order [*dispositio*] or series of changes that can take place in time, so too, we understand nothing in space but the possible order of bodies" ("On Body and Force, against the Cartesians"; GP IV, 394 / AG, p. 251); "[space] is a relationship: an order, not only among existents, but also among possibles as though they existed" (A VI, 6, 149; G. W. Leibniz: *New Essays on Human Understanding*, transl. by Peter Remnant/ Jonathan Bennett, Cambridge 1996, p. 149); "Space is the order of coexisting things, or the order of existence for things which are simultaneous" ("Metaphysical Foundations of Mathematics"; GM VII, 18 / L, p. 666); "[…] space is no more real than time, that is, […] space is nothing but the order of coexistents, just as time is the order of things that have existed before" ("Remarks on George Berkeley's *Principles of Human Knowledge*", AG, p. 307).

[3] "Leibniz's 5th Letter", § 47, LC, pp. 70–71.

family members, and not by her supposed absolute place in an independent genealogical sphere.

In like manner, space is nothing but a set of relations between coexistent things, and there is no independent spatial entity over and above these things and their relations. Again, the place of a thing is determined by its spatial relations to other things, namely how it is situated in relation to them and its distance from them, and not by some absolute position in an independent space. The place of a car driving northbound along a two kilometers one-way street can be determined by its relation to the street and the buildings along it. First, it is on the southern side of the street, near the buildings at the beginning of the street. After a couple of minutes, it is on the northern side of the street, near the buildings at the end of the street and two kilometers from the beginning of the street. A second car, starting now the same route, is *at the same place* where the first was a couple of minutes ago. To say that it is "at the same place" is not to say that it fills the same part of an absolute space earlier filled by the first car, but simply that it bears the same relation to the street and the surrounding buildings as the first car did a couple of minutes ago.[4]

On Leibniz's account, then, space has no independent but merely derivative reality. It is not a self-subsistent "container" which makes the existence of objects possible. Rather, objects are logically prior to space: its reality is derived from and dependent on objects. Accordingly, one cannot literally mean that "things are in space": things cannot actually be in space, because space is nothing over and above coexistent objects. Instead, this phrase has to be understood as indicating that things bear spatial relations to one another as explained above.[5]

The reality of space is further downgraded in Leibniz's account by his additional two theses, that is, the theses of ideality and phenomenality of space. The ideality thesis follows from the definition of space as relational and from Leibniz's account of relations. Leibniz maintains that relations are essentially ideal, since reality ultimately consists of substances and their accidents and relations can be neither one of these modes of reality.[6] Consequently,

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[4] See Leibniz's definition of place in his "5th Letter to Clarke", § 47, LC, pp. 69–70, and his consequent definition of space: "[…] that which comprehends all those places, is called space"; "[…] space results from places taken together."

[5] For a lucid exposition and criticism of Leibniz's arguments for his relational definition of space in the correspondence with Clarke, see Nick Huggett (ed.): *Space from Zeno to Einstein. Classic Readings with a Contemporary Commentary*, Cambridge 1999, pp. 160–168.

[6] A relation between two things is not itself a thing or a substance. Furthermore, it cannot be a property of a thing or an accident, "for if so, we should have an accident in two subjects, with

space, being nothing but a set of relations, is not a real but an ideal thing or a mental construct. The thesis that space is phenomenal is an independent one and does not follow from the former two theses regarding space. According to this thesis, space belongs to the phenomenal realm of physical things, and not to the fundamentally real sphere of substances or monads. That is, space consists in relations between physical things, and not between ultimately real substances. This does not, however, turn space into a fiction. Spatial relations still express truths, since they denote actual relationships between physical objects, which, although not ultimately real, are still grounded in true realities and, therefore, considered "well founded phenomena"[7].

This account introduces a metaphysics of three levels of reality: at the ground level are the genuinely real constituents of all reality, namely, substances; the second level consists of physical objects, which are aggregates or resultants of substances and, therefore, qualify as well founded phenomena;[8] at the third level stand space and time, which consist in relations between physical objects and, therefore, may qualify as well founded phenomena of second order.[9]

In a letter to Des Bosses, Leibniz explains the reason that led him to his unique metaphysics and view of space:

> "I consider the explanation of all phenomena solely through the perceptions of monads functioning in harmony with each other, with corporeal substances rejected, to be useful for a fundamental investigation of things. In this way of explaining things, space is the order of coexisting phenomena, as time is the order of successive phenomena, and there is no spatial or absolute nearness or

one leg in one, and the other in the other; which is contrary to the notion of accidents." And "being neither a substance, nor an accident, it must be a mere ideal thing", "Leibniz's 5th Letter", § 47, LC, p. 71.

[7] For a discussion of Leibniz's three main theses regarding space, see Nicholas Jolley: *Leibniz*, London 2005, pp. 84–89.

[8] This idea appears at a multitude of places. See for example "Letter to Arnauld, 9 October 1687"; A II, 2, 249 / LA, p. 152. "First Truths"; A VI, 4, 1648 / L, p. 270. "Letter to de Volder, 30 June 1704"; GP II, 268–270 / L, p. 536–537. "Letter to de Volder, 1704–1705"; GP II, 275–276 / AG, pp. 181–182. "Letter to Des Bosses, 15 March 1715"; GP II 492 / L, p. 609. "Letter to Nicolas Remond, 10 January 1714"; GP III, 606 / L, p. 655. "Letter to Nicolas Remond, 11 February 1715"; GP III, 636 / L, p. 659. "Remarks on George Berkeley's *Principles of Human Knowledge*", AG, p. 307. "Against Barbaric Physics"; GP VII, 344 / AG, p. 319.

[9] On the three ontological levels in Leibniz's metaphysics, see Jill Vance Buroker: *Space and Incongruence. The Origin of Kant's Idealism*, Dordrecht 1981, pp. 35–37. It is sometimes argued that the ascription of well founded phenomena to space and time is less appropriate, since they are merely mental constructs, and that Leibniz accordingly in later texts prefers to classify them as ideal rather than well founded phenomena. On this point, see Robert Merrihew Adams: *Leibniz. Determinist, Theist, Idealist*, New York 1994, pp. 253–255.

> distance between monads… In this conception, also, there is involved no extension or composition of the continuum, and all difficulties about points disappear. It is this that I tried to say somewhere in my *Theodicy* – that the difficulties in the composition of a continuum ought to warn us that we must think far differently of things."[10]

Leibniz suggests here that it is the consideration of the difficulties in the composition of continuous entities that led him to "think far differently of things" and to advance his original metaphysics and account of space. In the *Theodicy*, he claims that this puzzle constitutes one of the "two famous labyrinths where our reason very often goes astray" and that it arises due to "lack of a true conception of the nature of substance and matter."[11] Now the problem of the composition of continuous things and the nature of substance and matter essentially involves two central issues: the composite nature of physical objects and the relation between objects and space.

On the one hand, Leibniz argues that composite objects ("beings by aggregation") draw their reality from their parts. If they were composed of parts which are also composite and so on to infinity, they would lack a foundation for their reality and would not be genuinely real. Therefore, to be real, they must ultimately be composed of true entities or substances, the hallmark of which is unity.

> "[…] every being by aggregation presupposes beings endowed with real unity, because every being derives its reality only from the reality of those beings of which it is composed, so that it will not have any reality at all if each being of which it is composed is itself a being by aggregation, a being for which we must still seek further grounds for its reality, grounds which can never be found in this way, if we must always continue to seek for them."[12]

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[10] "Letter to des Bosses", 16 June 1712; GP II, 450–451 / L, p. 604.

[11] See: "There are two famous labyrinths where our reason very often goes astray: one concerns the great question of the Free and the Necessary, above all in the production and the origin of Evil; the other consists in the discussion of continuity and of the indivisibles which appear to be the elements thereof, and where the consideration of the infinite must enter in. The first perplexes almost all the human race, the other exercises philosophers only. I shall have perchance at another time an opportunity to declare myself on the second, and to point out that, for lack of a true conception of the nature of substance and matter, people have taken up false positions leading to insurmountable difficulties, difficulties which should properly be applied to the overthrow of these very positions" ("Theodicy", preface; GP VI, 29 / H, p. 53–54). Cf. "Theodicy – Preliminary Dissertation", § 24; GP VI, 64–65 / H, p. 88–89; "On Freedom"; A VI, 4, 1654 / L, p. 264.

[12] "Letter to Arnauld, 30 April 1687"; A II, 2 184 / AG, p. 85. Cf.: "The monad […] is nothing but a simple substance which enters into compounds […] There must be simple substances, since there are compounds, for the compounded is but a collection or an aggregate of simples […] The monads are the true atoms of nature; in a word, they are elements of things. We need

Although this line of argument became a strong rationalistic tenet,[13] it may also draw its ground from the nature of mechanical explanation. To explain a physical object mechanically is to derive its properties from the properties of its parts. The properties of the parts depend, in turn, on the properties of the parts of the parts, and so on. Now if this mode of explanation is to work, it seems that a certain ground floor of fundamental parts with primitive properties has to be postulated.[14]

On the other hand, the spatial extension of objects may seem to imply that their division into parts proceeds indefinitely. Space, as a continuous magnitude, is infinitely divisible. A spatial region, however small, can always be further divided; its division never ends in indivisible, simple parts of which it is composed. And if this essential characteristic of space is somehow carried over to objects, then they too cannot be composed of simple parts. This is clearly the case in Descartes's account. Descartes identifies space with matter and maintains that the nature of body consists in extension.[15] Therefore, on his account, objects, just like space, are not made up of simple parts.[16] In addition, absolutist views of space may also be taken as implying the same conclusion. On

fear no dissolution in them, and there is no conceivable way in which a simple substance can be destroyed naturally" ("Monadology" §§ 1–4; GP VI, 607 / L, p. 643). See also "New System", § 3; GP IV, 478–479 / L, p. 454. "New System", § 11; GP IV, 482 / L, p. 456. "Principles of Nature and Grace", § 1; GP VI, 598 / L, p. 636. For a discussion of the unity and simplicity of substances, see Jolley: *Leibniz*, pp. 37–41.

[13] Christian Wolff argues that simples are the ground of composites: "If there are composite things, there must also be simple beings. For if no simple beings were present, then all parts – they can be taken to be as small as you might ever like, even inconceivably small parts – would have to consist of other parts. But then, since one could provide no reason where the composite parts would ultimately come from, just as little as one could comprehend where a composite number would arise from if it contained no unities in itself, and yet nothing can be without a sufficient ground […], one must ultimately admit simple things from which the composites arise" (Christian Wolff: "Rational Thoughts on God, the World and the Soul of Human Beings, Also All Things in General", § 76, in: W, p. 17). Alexander Baumgarten also reasons that if there are composites, there must be simples: "A composite cannot exist, except as the determinations of others […] Now, apart from composites, there are only simples […] Therefore, if composites exist, monads exist" (Alexander Baumgarten: "Metaphysics" § 245, in: W, p. 103).

[14] This line of thought seems to be implied in Isaac Newton: *Opticks*, New York 1979, pp. 400–404.

[15] See: "[…] the same extension which constitutes the nature of body also constitutes the nature of space" (René Descartes: *Principles of Philosophy* II, § 11, transl. by Valentin R. Miller and Reese P. Miller, Dordrecht 1983, p. 43).

[16] See: "We also easily understand that it is not possible for any atoms, or parts of matter which are by their own nature indivisible, to exist. The reason is that if there were such things, they would necessarily have to be extended, no matter how tiny they are imagined to be. We can, therefore, still conceive of each of them being divided into two or more smaller ones, and thus

these views, space, as a receptacle in which bodies extend, is a condition for the existence and structure of bodies. Therefore, bodies are essentially extended entities. Put differently, spatial extension is a primary quality of bodies and this implies their infinite divisibility.[17]

Now Leibniz accepts both seemingly conflicting views. He both agrees that physical objects are, in some sense, infinitely divisible and insists that simple substances essentially constitute composite objects. His way out of this labyrinth rests on his original conception of space and his threefold ontology: by downgrading the ontological status of space, Leibniz is able to discard the idea that extension in space is a primary property of objects,[18] and to propose an entirely different understanding of the constitution of objects. Thus, on the phenomenal level, physical objects are indeed infinitely divisible extended masses in space. But on a deeper metaphysical level, they are ultimately constituted by "metaphysical points" or simple substances. Construed in a way analogous to spirits, these metaphysical points are active simple entities, and their counterparts in the physical realm are corporeal substances essentially made up of physical forces.[19]

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we know that they are divisible. For it is impossible to [clearly and distinctly] conceive of dividing anything without knowing, from that very fact, that it is divisible" (ibid., § 20, pp. 48–49).

[17] It is important of course to distinguish between different meanings of divisibility in this context: see the distinction between *formal* and *actual* divisibility in note 21 below.

[18] See "Discourse on Metaphysics", § 12; A II, 4, 1545 / L, 309–310. "Letter to Arnauld, 30 April 1687"; A II, 2, 187–188 / AG, pp. 86–87. "Letter to Arnauld, 9 October 1687"; A II, 2, 249–250 / LA, pp. 152–153. "A Specimen of Discoveries"; A VI, 4, 1622 / PP, pp. 81. "On Body and Force, against the Cartesians"; GP IV, 393–394 / AG, pp. 251. "Specimen Dynamicum"; GM, VI, 246–247 / L, pp. 444–445. "Letter to De Volder, 24 March 1699"; GP II, 169–170 / L, pp. 516. "Letter to De Volder, 23 June 1699"; GP II, pp. 182–183 / L, p. 519. On Leibniz on the idea of extension, see Charlie D. Broad: *Leibniz. An Introduction*, London 1975, pp. 54–55; Glenn A. Hartz: *Leibniz's Final System. Monads, Matter and Animals*, London 2007, pp. 63–65.

[19] In "New System" (§ 3, GP IV, 478–479 / L, p. 454; § 11, GP IV, 482 / L, p. 456) Leibniz concludes by elimination that the basic elements constituting composites must be metaphysical points. These elements can be neither material atoms, since they are "contrary to reason," nor mathematical points, since they are limits rather than parts of extended objects. Hence, the basic elements must be metaphysical points. For an analysis of Leibniz's discussions of divisibility and simple parts of matter, see Hartz: *Leibniz's Final System*, ch. 2 and 3. Hartz shows that Leibniz is concerned with two aspects of division of matter. From one point of view, matter is regarded as infinitely *divisible* into ever smaller mass-parts. From another, matter is actually *divided* into simple substances. This distinction, Hartz suggests, enables Leibniz to finally find his way out of the "labyrinth of the continuum" (Hartz: *Leibniz's Final System*, p. 72).

2. Kant's Version of Relational and Real Space

In his 1756 *Physical Monadology*, Kant uses a Leibnizian conception of relational space, together with a dynamical model of matter, to resolve the controversy regarding the theory of monads and the constitution of matter between Leibnizian-Wolffian metaphysicians and Newtonian thinkers in the 1740s and 1750s Berlin Academy.[20] As Leonard Euler observed, the key point in the controversy was the conception of spatial extension.[21] He succinctly summarized the Leibnizian line of thought as follows. Since it is "a completely established truth that extension is divisible to infinity, and that it is impossible to conceive parts so small as to be unsusceptible of further division," philosophers who reject the infinite divisibility of bodies "do not impugn this truth itself, but deny that it takes place in existing bodies" by downgrading extension to the status of a merely abstract, ideal property.[22]

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[20] The newly reestablished Berlin Academy was torn between Newtonians and Wolffians. The former were led by the president of the Academy, Pierre Louis Maupertuis, and the Academy's preeminent mathematician and scientist, Leonard Euler. Despite the fact that Wolff declined King Frederick the Great's invitation to co-lead the Berlin Academy, Wolffians were still dominant and serving at key positions in the Academy (e.g. Samuel Formey, the secretary of the Academy). The Academy made monadology the subject for the prize contest of 1747. Scholars were asked to clearly formulate the doctrine of monads and then to decide whether it could be decisively proved or refuted. Anti-monadists objected that monads violated the established law of inertia. To posit that material elements are endowed with spontaneous activity and inner powers capable of altering the states of the bodies which they constitute is at odds with the essential passivity of objects professed by this law. On their view, observed changes in the actual world must be exclusively accounted for by means of external forces. They also argued that the simplicity of monads conflicts with the infinite divisibility of the space occupied by material bodies. It appeared inexplicable to them that infinitely divisible bodies could be constituted by simple substances or elements. An anti-monadist essay won the contest, but the debate was not settled thereby. For detailed historical accounts of the conflict, see Lewis White Beck: *Early German Philosophy. Kant and His Predecessors*, Cambridge 1969, pp. 314–319; Ronald Calinger: "The Newtonian-Wolffian Controversy. 1740–1759," in: *Journal of the History of Ideas* 30 (1969), pp. 319–330; Irving Polonoff: *Force, Cosmos, Monads and other Themes of Kant's Early Thought*, Bonn 1973, pp. 77–89; Alison Laywine: *Kant's Early Metaphysics and the Origins of the Critical Philosophy*, Atascadero 1993, pp. 27–31.

[21] See Leonard Euler: "Letters to a German Princess", in: W, p. 213: "The controversy between modern philosophers and geometers […] turns on the divisibility of body. This property is undoubtedly founded on extension, and it is only in so far as bodies are extended that they are divisible and capable of being reduced to parts".

[22] Ibid., The debate spread beyond the walls of the Academy and attracted the attention of non-professional intellectuals and laymen as well. Euler, one of the central figures in the debate, vividly depicts the agitation it aroused in the German world: "There was a time when the dispute about monads employed such general attention and was conducted with so much warmth that it forced its way into the company of every description, that of the guardroom not excepted.

Although Kant advocated a relational conception of space, he did not submit to this line of thought. Kant sought for a theory that would acknowledge both the infinite divisibility of space and the claim that physical objects consist of simple substances, but without downgrading space to merely ideal thing and without construing substances as mental. He thus proposed a theory of relational but *real* space and of monads or simple substances which are essentially *physical*. This theory of physical monads has the advantage that it avoids the problem of explaining how the physical and spatial properties of material objects arise from non-extended, mental Leibnizian monads, of which bodies are supposed to be composed.

The question is how it is possible for simple physical substances to be in space or to fill a space without thereby loosing their simplicity, given that space is infinitely divisible. The answer turns on Kant's insight that filling a space does not necessarily entail being composed of independent parts. Something filling a space must be composite only on the additional assumption that the *formal* divisibility of space entails the *actual* divisibility of things in space and hence their non-simplicity.[23] To avoid this additional assumption and the conclusion that it implies, Kant advances a relational view of space and a dynamical model of matter. These two doctrines allow him to maintain both that bodies extend in space and that they consist of simple parts.

Regarding space, Kant claims that "since space is not a substance but a certain appearance of the external relation of substances, it follows that the possibility of dividing the relation of one and the same substance into two parts is not incompatible with the simplicity [or] unity of the substance"[24] In

There was scarcely a lady at court who did not take a decided part in favor of monads or against them. In a word, all conversation was engrossed by monads – no other subject could find admission" (Euler: "Letters", in: W, p. 218).

[23] By "actual" divisibility I understand the logical possibility to separate and distance parts from one another. It is clear that space is not divisible in this meaning: it is logically impossible to distance one region of space from the regions adjacent to it. In the case of space, it is possible merely to identify parts or regions and mark borders between them, which means that space is only "formally" divisible. And see the quotation from Kant in the following footnote.

[24] "Physical Monadology" = PM, 1, 480. Writings by Kant are cited by section number (if applicable) and volume and page number of *Kants Gesammelte Schriften*, ed. by the German Academy of Sciences, Berlin 1900–. Translations to English are from the *Cambridge Edition of the Works of Immanuel Kant*, ed. by Paul Guyer and Allen Wood, Cambridge 1992–. See also: "The division of space […] is not the separation of things, of which one is set apart from another and has a self-sufficient existence of its own. It rather displays a certain plurality or quantity in an external relation. Since this is the case, it is obvious that a plurality of substantial parts does not follow from the division of space. Since it is this plurality alone which would be

other words, space depends on external relations between physical substances. It is not a substance or an independent entity which is logically prior to physical substances. Hence, it is not a condition for their existence and, therefore, they need not assume its structure and admit infinite divisibility.

Put differently, spatial properties are not primitive properties of physical objects. They are not something which objects possess simply because they exist. For example, a thing existing on its own without any actual connections to other things has no *spatial place*. To have a place, it must be a part of a world, namely, a system of things which bear *actual* relations and interactions among one another.[25] Having a spatial position thus presupposes external relations. And these, in turn, are derived from the reciprocal actions which bodies exercise upon one another by means of their forces.

Similarly, the *spatial extension* of physical objects depends on the forces which constitute the very essence of matter. On Kant's dynamical model of matter, material objects are composed of physical monads, which are point-like elements exerting repulsive and attractive forces. Repulsion is stronger near the point-like element, while attraction is stronger at greater distances. The set of equilibrium points between repulsion and attraction (i.e. the points where the monad neither repels nor attracts other monads) defines the limit of the spatial extension of a physical monad. It is clear, then, that though it is possible to discern different spatial parts in the sphere of extension of the monad, it is not possible to separate or distance these parts from one another, since they all depend on and radiate from the same point-like source of forces. Hence, although it extends in space and fills a space, the monad is nonetheless simple.[26]

To sum up, Kant's version of relational space and his model of matter provide an alternative way out of the labyrinth of the continuum. Note that for Kant, space is not derived, as for Leibniz, from mere *apparent* external relations between phenomenal objects constituted by "windowless" monads, but rather from genuine reciprocal actions of material elements upon one another in virtue of their physical forces. Therefore, for Kant space is relational and

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opposed to the substantial simplicity of the monad, it is sufficiently clear that the divisibility of space is not at all opposed to the simplicity of the monad" (PM, 1, 480).

25 This definition of a world recurs throughout Kant's pre-critical texts. See for example "Living Forces", § 8, 1, 22–23; "New Elucidation", 1, 414; "Inaugural Dissertation", § 2, 2, 390.

26 For a detailed account of Kant's dynamical model of matter in the "Physical Monadology", see Idan Shimony: *The Antinomies and Kant's Conception of Nature*, Tel Aviv 2013, pp. 35–43.

real.[27] And this is enough to resolve the problem of the composition of physical objects.

3. Boscovich on Derivative and Discrete Space

Roger Boscovich also put forward an account which regards space as derivative. But he approached the subject from a different angle. His main task in his 1758 *Theory of Natural Philosophy* was to settle the problem regarding collisions between bodies. This led him to a dynamical theory of material elements similar to that of Kant.[28] Boscovich was reluctant to enter the puzzle concerning the nature of space and time, since he thought "that this is merely a question of terminology."[29] Nevertheless, he made some contentious claims on this issue and presented an intriguing view of derivative space.

On Boscovich's account, local and temporal properties are real modes of existence of material elements: "Any point [of matter] has a real mode of existence, through which it is where it is; and another, due to which it exists at the time when it does exist. These real modes of existence are to me real time and space."[30] Since real time and space are nothing but these modes of

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[27] As Lewis White Beck noted, for Kant "Space must be ontologically *real*, but it need not be ontologically *primitive*"; Beck: *Philosophy*, p. 447).

[28] Boscovich accepted Leibniz's criticism of the view that matter is composed of perfectly hard and undeformable elements (for Leibniz's criticism, see Idan Shimony: "What is (the) Matter – Locke, Leibniz, and the Controversy that Could not Take Place," in: Herbert Breger/Jürgen Herbst/Sven Erdner (eds.): *Natur und Subjekt. IX. Internationaler Leibniz-Kongress*, Hannover 2011, pp. 1070–1079, here p. 1078). If that were the case, then while bouncing in collision, elements would change their motion in an instant. This is a violation of the principle of continuity, which Boscovich regarded as a primary principle of nature. Furthermore, such a change involves infinite acceleration and therefore, in accord with Newton's force law, infinite force. Hence, Boscovich proposed a dynamical view of matter which admitted the elasticity required for observing the principle of continuity. He elaborated a system of point particles exerting forces on each other and making up material bodies. The main difference between the systems of Kant and Boscovich is that Boscovich postulated one unified force with changing influence instead of an interplay of two distinct forces. According to Boscovich's force law, the force projected by a point particle repels at very short distances and increases infinitely as the distance diminishes infinitely. At somewhat farther (but still rather short) distances, the force varies between repulsion and attraction in a wave-like manner. At greater distances, the force attracts and weakens with the distance in accordance with Newton's inverse square law of attraction (Roger J. Boscovich: *Theory of Natural Philosophy*, transl. by James Mark Child, Cambridge 1966, §§ 7–15.).

[29] Ibid., § 142.

[30] Ibid., § 197.

existence of material elements, and since, further, matter in Boscovich's theory is composed of indivisible points and does not continuously extend, real time and space are also discrete rather than continuous.

The continuity we ascribe to space is merely *ideal*. When we abstract from the actual points of matter and conceive the *possibility* of interposing as many points as we like between any two given points, we form for ourselves the idea of an *imaginary* continuous space.[31] Thus Boscovich concludes: "I recognize no coexisting continuum… for, in my opinion, space is not any real continuum, but only an imaginary one."[32]

One decisive feature of Boscovich's theory is the priority of matter over space. Discrete points of matter are the fundamental elements of his account. Everything else depends on them and the force law governing their activity. Thus, even though Boscovich wishes to stay away from the dispute regarding the nature of space, his theory implies a version of a derivative view of space, one that, moreover, entails the discrete nature of real space from the non-continuous character of material points.

4. Conclusion

I discussed in this paper Leibniz's account of relational space and its elaborations by Kant and Boscovich. All three thinkers regarded matter as logically prior to space and advanced relational and derivative views of space. Leibniz argued for relational and ideal space in order to resolve the problem of the constitution of matter. Kant had the same motivation for suggesting a relational account of space. Yet he suggested that to resolve this problem it is sufficient to postulate a relational and real space and monads which are physical rather than mental. For Boscovich, the view that real space is derivative and discrete was the outcome of a theory of matter designed to preserve Leibniz's principle of continuity. Thus, Leibniz's notion of relational space proved to be a fruitful philosophical idea. It yielded bold and intriguing attempts to decipher the nature of space. For all three thinkers, the relational account of space was combined with a dynamical view of matter. Thus it was integrated in theories of nature that introduced novel scientific ideas: Leibniz's theory of nature suggested, for example, a rudimentary formulation of the principle of conservation of energy, while the Kant-Boscovich model of matter is of historical

[31] See ibid., § 198.
[32] Ibid., § 142.

importance as the forerunner of 19th century field theories and certain dynamical conceptions of matter in modern physics.[33]

[33] For an analysis of Leibniz's discussion of conservation principles, see: Idan Shimony: "Leibniz and the Vis Viva Controversy," in Marcelo Dascal (ed.): *The Practice of Reason. Leibniz and His Controversies*, Philadelphia 2010, pp. 51–73. For a systematic survey of the Kant-Boscovich model of matter, see Thomas Holden: *The Architecture of Matter. Galileo to Kant*, Oxford 2004, pp. 236–272. See also Max Jammer: *Concepts of Force. A Study in the Foundations of Dynamics*, New York 1962, pp. 158–187; Thomas Hankins: "Eighteenth-Century Attempts to Resolve the Vis viva Controversy," in: *Isis* 56 (1965), pp. 281–297, here pp. 291–297; Jeffrey Edwards: *Substance, Force, and the Possibility of Knowledge. On Kant's Philosophy of Material Nature*, Berkeley 2000, pp. 103–105.