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Recensione

V. De Risi (ed.), *Leibniz and the Structure of Sciences. Modern Perspectives on the History of Logic, Mathematics, Epistemology*

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Research on Leibniz's role in the history of sciences and especially in the history of mathematics has a long tradition. The book edited by Vincenzo De Risi is a remarkable scholarly contribution to Leibniz's view on the sciences.

As the title indicates, the focus is twofold: First, it is an investigation into Leibniz's works on logic, mathematics, and epistemology. It elaborates a far-reaching companion to his contributions to those fields, especially considering them in terms of their function within the structure of science as a whole.

Second, the book stresses the modern perspectives on Leibniz's role in the history of logic and sciences. Thereby the authors claim to overcome the anachronistic tendencies in traditional readings of Leibniz as the inventor of modern logic, famously displayed by Russell's analysis in his book on Leibniz. Instead of generalising his innovations, each of the articles focuses on particular systematic *topoi* and works out comparisons between contemporary questions in mathematical logic or philosophy of science and Leibniz's way of dealing with similar problems. The volume aims to provide the basis for critical analysis of both the Leibnizian approach to the scientific fields in question and the historical development of the epistemology of logic and the sciences by the end of the 17th century.

Each article deals with a particular problem discussed in modern philosophy of science and compares it to relevant parts of the Leibnizian system. The book starts with two investigations of Leibniz's logic and of its metaphysical applications: *Leibniz on the Logic of Conceptual Containment and Coincidence* by Marko Malink and Anubav Vasudevan and *Leibniz's Mereology in the Essays on Logical Calculus of 1686-1690* by Massimo Mugnai. Richard Arthur's *Leibniz in*

Cantor's Paradise: A Dialogue on the Actual Infinity presents a fictional afterlife meeting between Leibniz and Cantor who discuss infinity and cardinality. The following essays *Leibniz on the Continuity of Space* by Vincenzo De Risi, *On the Plurality of Spaces in Leibniz* by Valérie Debuiche and David Rabouin, and *One String Attached: Geometrical Exactness in Leibniz's Parisian Manuscripts* by Davide Crippa examine the properties of space in connection to the logical foundations of geometry. The final articles apply the mathematical perspectives to physics and the epistemology of sciences: *Leibniz and the Calculus of Variations* by Jürgen Jost and *Teleology and Realism in Leibniz's Philosophy of Science* by Nabeel Hamid.

De Risi's arrangement of the articles follows the systematic path from pure logic to geometry and finally to physics, which can be seen as a classical triad in philosophy of science. Instead of limiting themselves to generalised examples, the authors provide a subtle historical and systematic analysis of Leibniz's works.

Malink/Vasudevan and Mugnai give a detailed analysis of Leibniz's logical writings presenting the close relation to his metaphysical doctrines. Mugnai argues that Leibniz's essays on the 'plus-minus calculus' written between 1686 and 1690, contain many of the ideas constituting current formal mereology. He combines the logical perspective with Leibniz's investigation of atomistic metaphysics in the *Dissertatio de Arte Combinatoria* (1666). Mugnai's study is a fruitful addition to the research on formal mereology, that often focuses either on the pure logical questions (e.g. the studies on axiomatization of CM and tensed CM by Paul Hovda in *Journal of Philosophical Logic* (2009, 2013)) and their origins in the surrounding field of the Lwów-Warsaw School (e.g. Ridder (2002)) or the rudimentary systematisation of part-whole theories by ancient and medieval authors. Mugnai's account adds the Early Modern Period to the map of part-whole theories that has been rather neglected so far. He shows that Leibniz differentiates between intensional and extensional containment which allows a modern reconstruction of extensional containment as a kind of classical mereological parthood relation. In addition to that, he works out Leibniz's notion of 'real addition' in a way similar to the contemporary notion of unrestricted sum. By referring to Leibniz's theory of infinite divisibility of matter (*gunkyness* as formal mereologists call it) Mugnai argues that the Leibnizian *Nothing* introduced in *Non Inelegans Specimen Demonstrandi in Abstractis* (1687) should not be reconstructed as a modern null-set. The crucial point in terms of the extensional interpretation of Leibniz's part-whole ontology is that classical extensional mereology allows to assume both infinite divisibility of matter and a kind of immaterial atom (the monad), that is – at least in terms of matter – literally *nothing*. Therefore, Mugnai draws the conclusion that Leibniz's treatment of atomistic doctrines cannot be reduced to a (modern) set-theoretical account concerning matter, but it rather resembles some hylomorphic tendencies in recent mereological research.

Debuiche and Rabouin give another example of metaphysical doctrines depending on the interpretation of mathematical assumptions. In their essay the authors ask whether there can be a plurality of spaces if geometrical laws are

necessary truths in God's mind. Leibniz's theory of space is interpreted as being relativistic: Every possible world – as an instance of concrete space – has its own intrinsic metric. The idea of the universe as a four-dimensional spacetime is quite common in contemporary physics and philosophy of time because it is well established by the general theory of relativity. Therefore, many authors like the idea that Leibniz has already worked out similar positions. But this interpretation faces the problem that ideal spaces – that is mathematical ones – only differ in their geometrical properties. If the geometrical properties of the actual world are necessary truths (as Leibniz supposes them to be), then there cannot be any other worlds different from the actual one.

This problem touches a classical topic in philosophy of science: The apparent gap between Newtonian mechanics depending on Euclidean space and general relativity, which presupposes non-Euclidean geometry.

Debuiche and Rabouin conclude that instead of using the ideal/actual distinction Leibniz faces the problem of apparently inconsistent properties of space by pointing at the conditional character of mathematical truths. The geometrical properties of the actual world are necessary for its consistency. But it is not necessary that God chooses exactly this set of principles instead of others. Other possible worlds also have their own necessary principles. For example, there can be a possible world with a Euclidean architecture and another possible world with a non-Euclidean architecture. Both of them depend on necessary geometrical truths, but it is not the same arrangement of principles (in this case the first one may have at least five axioms of space, while the latter has only four).

So Debuiche and Rabouin argue that – like in contemporary logical pluralism – the Leibnizian cosmos includes necessary mathematical truths, which have a kind of transworld validity. But the possible worlds in God's mind do not need to realise every single one of those truths. By arguing so, the authors preserve the quite modern interpretation of Leibniz's relativistic theory of space and separate it from discussions about the actual/possible distinction. As the authors finally state, the question remains: what encourages God to actualize *this* world instead of others? Possible worlds are consistent (otherwise they would not be possible). So consistency alone cannot be the motivation of actualization. There seem to be additional metaphysical principles like simplicity and sufficient reason, which extend the pure mathematical argumentation.

Therefore, the problem of the plurality of spaces is another example of Leibniz's twofold way of argumentation: Mathematical questions are usually interwoven with metaphysical questions and *vice versa*.

One main aspect of the book is this inseparable relation between mathematical and metaphysical thoughts in Leibniz, which is knowledgeably presented by each of the authors. De Risi's volume provides a high level of historical adequacy in Leibniz-related research. Simultaneously the book is a rich source for contemporary logicians and philosophers of science, who want

to get an in-depth analysis of both the technical and the historical development of classical problems in philosophy of science and mathematics.