Russell's 1927 *The Analysis of Matter* as the First Book on Quantum Gravity

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Abstract. The goal of this note is to bring into wider attention the often neglected important work by Bertrand Russell on the foundations of physics published in the late 1920s. In particular, we emphasize how the book *The Analysis of Matter* can be considered the earliest systematic attempt to unify the modern quantum theory, just emerging by that time, with general relativity. More importantly, it is argued that the idea of what I call *Russell space*, introduced in Part III of that book, is more fundamental than quantum theory, general relativity, and quantum gravity since the topological ordinal space proposed by Russell would naturally incorporate into its very fabric the emergent nature of spacetime by deploying event assemblages, and not spacetime or particles, as the fundamental building blocks of the world.

1. Introduction

In 1927, Bertrand Russell published a very remarkable book entitled *The Analysis of Matter* [1], which is based on a series of lectures he delivered sometime earlier. My goal here is not turning out another review of this nearly one-hundred-year-old book. Instead my purpose is to provide some general remarks on the overall philosophical scope of such quite unusual work in the history of ideas, especially in regard to its possible connection with the still ongoing problem of finding a general working theory of quantum gravity [2–5]. Indeed, the completion of modern quantum theory in 1927 coincided with the publication of this work. As is well known, Russell had always been very informed about the latest development in physics and mathematics [6, 7], and in the book he cites the just published fundamental papers by Heisenberg, Dirac, Weyl, and other founders of modern physics that were being turned out in the productive five-year period 1923-1927 that eventually shaped our understanding of physics and nature [8]. However, Russell's acute awareness of the radical changes taking place in science during that time, most importantly the fundamentally *nonclassical* nature of the microscopic world of quantum mechanics, did not deter him from pursuing the very difficult task of building a unified framework for gravity and the quantum world. He attempted to do so using both *philosophical* means (Part I and II), but more interestingly through *mathematical philosophy* (Part III). His background as probably the most important mathematical philosopher of the twentieth century [9, 10] did eventually help in making the formulation more comprehensive than earlier and even later works.

My main thesis in this short article can be summarized by the following two observations:

(i) Russell had embraced in Part I and Part II of his book a somehow traditional "Russellian" style of doing the philosophy of science, where emphasis is usually laid on the relation between nature and perception (British empiricism) and the associated metaphysics, e.g., in the spirit of Whitehead's earlier work [11].

(ii) The real contribution of Russell's book, however, is in Part III, which is often neglected by mathematicians and philosophers of science. Here, his tone has shifted noticeably from traditional philosophy of science toward fundamental ontology in the style of some of his other books such as [9, 10, 12–14].

I deal with the first observation in Sec. 2 below where the metaphysical and epistemological aspects of Russell's presentation are revisited (very briefly.) On the other hand, the more radical development pertaining to fundamental ontology are dealt with (admittedly only at the high level) in Sec. 3.

2. Metaphysics vs Epistemology and the Shift Toward Fundamental Ontology in Russell's Account

Part I may be viewed as a philosophical introduction to the latest developments in gravitation and quantum theory. For the classical theory (general relativity), he draws on the works of Weyl [15] and Eddington [16, 17] to reformulate the problem in the most abstract and far-reaching form possible (gravity as a gauge field theory, though, naturally enough, the present modern form [18] is still not there yet.) Within the entire content of Part I, the most remarkable chapter is the one entitled *Measurement*, which in spite of being not very conclusive succeeded in providing some of the most penetrating remarks on the general abstract formulation of the problem of measurement in theoretical physics I am aware of. In this particular location one can feel resonances with the third volume of *Principia Mathematica* [14], i.e., the ontology of magnitudes, which dates back to certain chapters in *The Principles of Mathematics* [9]. However, I will say nothing more on measurement in the remainder of this paper.

Part II deals mainly with epistemological issues and is probably the least remarkable in the entire book. Here, the now classic attention often paid by British philosophers to the problem of the relation between sense perception and sense data on one hand [19], and the construction of theories of nature on the other [20], is highlighted and developed in a series of short chapters typical of Russell. The future (and last important) 1948 book by Russell, *Human Knowledge* [21], would somehow attempt a grand synthesis of these two dimensions of the philosophy of nature in which epistemological considerations related to the problem of perception are linked to the deductive and inductive (probabilistic) foundations of certainty and belief in theory construction processes. While in my opinion there has not been much attention paid to Russell's 1927 book within the secondary literature in general, the notable few exceptions tend to concentrate on the global epistemological aspects of the work [22].

If Part I can be loosely described as a "metaphysical account" of classical and quantum physics, while Part II is mainly concerned with the epistemological foundations behind our attitude toward nature, then Part III qualifies as the "ontological turn" of Russell's thought where the philosopher of nature now strives to recalibrate his resources in order to take up the fundamental ontology of the world at the very basic and abstract level of his best (earlier) works [9,10]. The various chapters in this part deal with a diverse array of highly technical subjects, probably more than in any other book by Russell (with the exception of *Principia* and the *Principles of Mathematics*.) Building on the emerging subject of general (set-theoretic) topology, especially the theories of Cantor, Urysohn, and Hausdorff [23], Russell's aim is to propose the most general concept of "space" possible, with an eye on quantum gravity.

There are several notable technical features in the Russell's program of Part III that will be taken up again in Sec. 3. For now, I would like to mention the all-important (and currently quite popular) theme of the *emergence* of spacetime. This is in fact a theoretical motif that was very well alive not only in the mind of Russell himself, but also Whitehead [11,24–26], Jakob von Uexküll [27], and before them even Mach [28] and William James [29] through their respective versions of neutral monism. The reason why Russell added the very technical Part III is that he wanted to defend a version of ontological monism that was dominant in his thinking at the time. The idea is that nature in its essence is both *abstract* and *material*. I propose to call this philosophical program *abstract materialism* [30], which is a rather specific view of nature that should be distinguished from various other versions such as the non-dualist ontologies of Spinoza [31], Leibniz [32], Schelling [33], Bergson [34–36], James [29], and Mach [28]. While all these ontologies (and Russell's) can be united in being a revolt against the dualism of Descartes and Kant (and possibly Hegel), they differ from the Russellian attitude by the degree in which their major orientation derives from the concept of *structure* and its various derivative thematic points of view. As a matter of fact, the fundamental concept of *structure* in physics, coupled with a fully-fledged structure-centric approach to the philosophy of nature (Nature *is* structure), a position already defended by Eddington [37], was taken up again by Russell's book but now implemented using the very sophisticated topological toolkits available from earlier Russellian forays into mathematics, logic, language, and epistemology [9,10,20,38,39]. One of the results obtained from such ambitious endeavour is something totally new and unprecedented: It is what I intend to dub *Russell space*, while arguing that it constitutes the most general topological space ever proposed in the literature so far.

3. The Concept of Russell Space

As I did with regard to the remarks on Parts I and II, no detailed examination of the contents of Part III will be given here. My objective is to reconstruct an interpretation of those particular elements in Russell's overall program that can be located in the outstanding (but rarely read) third division of his book. While Parts I and II have already drawn some critical reviews and examinations in the secondary literature, it remains true that in the main there has been a tendency to focus on the later book *Human Knowledge* [21], first published in 1948, which contains some of the ideas developed in *The Analysis of Matter*, Part III. However, careful reading of the two books reveals essential differences. *Human Knowledge*, as the title explicitly says, focuses on the foundations of our knowledge of nature, i.e., it is essentially a work on the epistemology of the natural sciences. Since Russell is no ordinary epidemiologist – his worldview already overladen with a heavy emphasis on metaphysics and ontology – it is only natural that his treatment of the subject of the foundations of scientific knowledge in the 1948 text will rework some of the technical constructions presented in Part III of the 1927 book. Nevertheless, the main emphasis of the epistemological approach is not on providing a general ontological matrix for the genesis of being, as I argue *was* in fact his intention in the earlier work *The Analysis of Matter*, but rather the narrower goal of integrating Russell's ontological theory of causality with the probabilistic inductive foundations of scientific knowledge in general, and the physical sciences in particular.

A need arises then to establish a more focused interpretive stand with respect to Part III of the 1927 book emphasizing its uniqueness and distinctiveness not only within the Russell Universe, but in the history of fundamental physics. There are two main objectives motivating my interpretation:

(i) Providing a very rough outline for a sketch of what I proposed above to call *Russell space.*

(ii) I seek to connect the subject with some contemporary "new ideas" on the emergence of spacetime in nature, especially within the framework of quantum gravity.

These two objectives will be briefly addressed in order. More detailed examination will be given in a future text.

What is the main idea of Russell space? Is this nothing but another example of one of those contemporaneous or future (with respect to Russell's time) "famous spaces" now populating, even sometimes overcrowding, mathematical physics such as Hilbert space, Banach space, Gelfand space, and so on? The very idea of an abstract mathematical space was relatively new by Russell's book time, being introduced into the field only a quarter of century earlier by several authors, chief among them is Russell himself in his 1900-1903 *magnum opus The Principles of Mathematics* [9,38]. But the germs of a concept do not contain the entire story, for Russell had been integrating several key ideas into the basic structure of general abstract mathematical space throughout the intervening years, notably the principle of *causality* and the ontology of the *event* [20].

Russell space is a supra-Cantorian generative matrix of structures. That is, it is not a concrete or a specific space such as the complex plane or Hilbert space, but a very abstract *reconfigurable* dynamic "metastructure" capable of "rewiring" itself in order to produce new structures. A Russell space then is a context-driven ontological framework for concretization. A given space *becomes* concrete when various, already individuated, fundamental elements (events) interact with each other in accordance to the Russellian principle of generalized causality, which is essentially a topological order relation with specific characteristics. The interaction of several nexuses of events may lead to the production of concrete/concretized spaces. The entire framework is *topological* in and through. An example is the production of spacetime "points," a theme that was already developed in an earlier book [20], and was also a favourite thread in Whitehead's early mature philosophical work [11].

The role of topology in Russell space should not be underestimated because at that time (1927), when the very concept of Hausdorff topological space was quite recent, it is truly astonishing that Russell, a philosopher and mathematician, would leave the emerging field of Riemannian geometry with its emphasis on the metric field in order to propose what is, in a nutshell, a topological theory of quantum gravity based on an underlying event ontology of the world. Using some original topological methods from his own work but also Hausdroff's, Russell demonstrated how to technically construct any space you need out of a nexus of topologically interacting events. Two applications of this general method are a provisional attempt to integrate Einstein-Eddington-Weyl concept of "dynamic spacetime" with the new quantum mechanics of

Heisenberg, Schrodinger, Dirac, Born, and Jordan that was taking its final shape at the time of the writing of the book itself.

Another application is the derivation of ordinary spacetime itself from the underlying events. This is the essence of Russell's (and Whitehead's) idea that in itself spacetime is not fundamental but should be derived from some more primordial level of nature, in his case the event structure of the world. In more recent times, the idea that spacetime is emergent have gained wide popularity, especially in the wake of John A. Wheeler's theory of "quantum foams" and similar concepts [40]. One can also recall David Bohm's speculative theories regarding the possible existence of a non-Lorentz invariant primordial random field-theoretic structural layer (sub-quantum fluctuations) underlying spacetime itself [41–43]. The idea of emergent spacetime was not invented by Russell. In fact, there is a strong evidence that the later Leibniz began to move into this direction in his mature philosophy, as can be sensed after reading some of his correspondence, especially with Arnauld [44]. But of course the theme of "emerging spacetime" has become quite popular in recent decades due to the increasing volume of researches conducted by some mainstream programs of quantum gravity such as noncommutative geometry, loop quantum gravity, causal net theories, string theory, Penrose spin foams and networks [2–4, 45–49]. While the technical contents of each of these competing research diagrams differ significantly from each other, what somehow unifies most of them is the belief that quantizing gravity implies quantizing spacetime itself, and hence forces classical spacetime to become an emergent structure, while a kind of "quantum spacetime," e.g., spacetime governed by a quantized metric field operator, is more fundamental.

It is interesting to note that, technically speaking, Russell space can reconfigure itself to produce either discrete or continuous spaces. This reflects Russell's conscious awareness that a more fundamental underlying space could very well turns out to be discrete rather than continuous (basically due to quantization.) The idea that spacetime might be ultimately discrete, say below the Planck length scale, is a popular subject nowadays. The most consistent proponents of this approach appear at the moment to be those working within loop quantum gravity, causal net theories, and few other research programs such as the group quantum field theory approach to gravity [50]. Regardless to which quantum gravity program will eventually succeed, Russell space is rich, general, and complex enough to incorporate the main traits of the ultimate victorious theory (if any) destined to dominate the crowded battlefields of quantum gravity. The reason is that Russell decided to deploy *ordinal* topological methods to implement reconfigurability in his generalized space concept. Being grounded in Cantorian set theory, Russell had no problems dealing directly with the actual infinite while invoking very strong principles such as the axiom of choice. Therefore, his reconfigurable ontological framework of spacetime genesis is sophisticated enough to accommodate a wide variety of potential concrete empirical inputs stemming from the ongoing research on quantum gravity, maybe by incorporating such inputs as "add-ons" to be appended into the ordinal nexus of the Russell space event assemblage engendering the very production of spacetime as such.

Finally, I would like to provide some critical remarks on Russell's concept of the event. As mentioned above, a core feature of Russell space is that it is a dynamic assemblage of fundamental basic building blocks called *events* (Whitehead's "blocks of becoming," a concept itself taken from Bergson.) Those events are more real than points.[1] In any case, event assemblages and Russellian causality (the latter is not identical to conventional causality in mainstream philosophy of science) are sufficient to derive the fundamental features of how the Russel space mechanism of producing "other emergent spaces" works in practice.[2] The production of spacetime is only one structural function implicit in Russell space. Other, more dynamic features (such as the incorporation of contextual fields) can be also integrated in order to extend the scope of the ontological framework [30].

The idea that underlying nature is a deeper, in a sense more primordial, level of the Real (an ontological layer that is comprised of event multiplicities) is older than Russell, dating back to at least Leibniz's monadology, which is a particularly famous example of monadic ontologies. The event-monad system was later invoked and used so brilliantly by Schelling in his profound 1800 book on the philosophy of nature [33]. Afterwards, the idea appeared with several thinkers such as Mach [28], James [29], Russell [20], Whitehead [11], and most recently the joint work of Deleuze and Guattari [55, 56]. All these philosophies of nature share a certain commitment to what one might roughly call "monadological pluralism," an attitude that seems to be closely allied to one version of monism or another. As we learned from Gilbert Simondon, Deleuze, and Guattari, pluralism and monism are very closely related to each other: multiplicity implies the univocity of being, and, conversely, univocal being can be expressed in multiple ways [55–58].

However, it should be pointed out that Russell's thinking about the nature of the event was heavily influenced by two other figures: Albert Einstein and Alfred North Whitehead. The mutual relationships between the three thinkers is very complex and detailed research into this subject must be left to other places. But some specific technical details in the construction of the event as a concept are relevant to my overall aim in this article. First, note that Einstein's influence on Russell had always been filtered through the latter's relation with Eddington on one hand, and Weyl on the other. Indeed, these last two writers had shaped the *mathematical* theory of general relativity and gravitation, essentially altering all subsequent discussions of the topic, in fact more so than Reichenbach's impact on spacetime theories. Reichenbach was "more Russellian than Russell himself," but, ironically, Russell was not always as Russelian as he should had been.

In fact, one of those moments where Russell appears to have *faltered* is in the issue of modeling events as "blocks of spacetime," an idea advocated by Whitehead's Bergsonian interpretation of Einstein's gravitational theory [59]. In such manner, Russell missed a great opportunity to *avoid* falling into the trap of *geometrizing* dynamics,[3] leading to the *pangeometrism* of contemporary mathematical physics, a problem that still haunts us up to today. Temporality cannot be modeled as another dimension in a 4-dimensional manifold. A better approach, probably closer to the intuition of time in Bergson and Heidegger [60], might be to think of the event as a *topological flow* [30] rather than an "eternal" or "frozen" block of becoming as in Whitehead [11]. It is Weyl's early stipulation that 'Einstein and Minkowsky had effectively "dynamized" space by introducing time as a fourth dimension' [15] that

[1]There is no complete, fully-worked out theory to be found in Russell's (nor in Whitehead's) accounts explaining how to derive the fundamental particles of physics from events, but hints and proposals on this subject matter abound in their texts, which stimulated a sizeable literature on interpretive strategies applied to Russell's and Whitehead's metaphysical systems, e.g., see [51–53].

[2]For more insight into Russell's unique concept of causality, see how Reichenbach used temporal order to derive fundamental structures in general relativity and gravitation [54].

[3]Reichenbach, but not Russell, succeeded in fully evading this geometric trap [54].

caused this unfortunate chain of confusions about the relation between dynamics and spacetime. A Russell space free of the Russellian-Whiteheadian portrayal of events as "blocks of spacetime" would have been considerably more open to current problems of dynamics and entropic flows. Time probably cannot be spatialized as was originally conceived by the founders of relativity in the form of a fourth dimension even if this dimension is declared "time-like" [61].

4. Conclusion

I looked into Russell's 1927 masterpiece on the philosophy of nature, *The Analysis of Matter*, and argued that this book, especially Part III, which is often neglected in the secondary literature, could be considered the first serious attempt to formulate a comprehensive conceptual framework for quantum gravity. Moreover, it appears that Part III of this work contains a concept of dynamic space, which I called Russell space, that is the most general framework for an ontological space proposed in the literature so far. Russell space can be used to understand the genesis or emergence of conventional spacetime as a case example and is able to handle both continuous and discrete spaces.

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