

# NO BACKGROUND

**James Read: Background Independence in Classical and Quantum Gravity,  
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It is not hard to find physicists describing in vivid terms the central lesson of the general relativity in terms of an intuitive idea that is often given the name *background independence*. Consider, for example, the following beautiful analogy made some time ago by Carlo Rovelli in the introduction to his textbook *Quantum Gravity*:

“In Newtonian and special-relativistic physics, if we take away the dynamical entities – particles and fields – what remains is space and time. In general-relativistic physics, if we take away the dynamical entities, nothing remains. The space and time of Newton and Minkowski are re-interpreted as a configuration of one of the fields, the gravitational field. This implies that physical entities – particles and fields – are not immersed in space, and moving in time. They do not live on spacetime. They live, so to say, on one another.

It is as if we had observed in the ocean many animals living on an island: animals on the island. Then we discover that the island itself is in fact a great whale. So the animals are no longer on the island, just animals on animals. Similarly, the Universe is not made up of fields on spacetime; it is made up of fields on fields (Rovelli 2004, p.9)

It is somewhat harder, however, to isolate what precisely the insight of background independence is supposed to amount to in formal terms. There is wide agreement that general relativity is background independent, but at least seven (and counting) definitions of what this is supposed to mean mathematically. Not only have none of these definitions proven without problems in the classical context, it is furthermore unclear to what extent the concept of background independence might be expected to survive in prospective quantum theories. This is despite the fact that advocates of the various programmes have

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variously utilised the property as a virtue of their own approaches, and its failure as a vice of their opponent's.

It is into these murky waters that James Read leads us in this dense yet rewarding short monograph. Whilst he does not seek to construct his own specific analysis of background independence as a property, Read does admirable work in synthesising a considerable body of work in physics and its foundations into a coherent and comprehensible form. Indeed, building on earlier work by [Belot \(2011\)](#), [Pooley \(2017\)](#), [De Haro \(2017\)](#), and others, one might plausibly understand Read's project to be the comprehensive cataloging of the various proposals together with their strengths and weaknesses in classical and, where possible, quantum form.

Read follows the main contours of the now classic discussion of [Pooley \(2017\)](#). This analysis starts by isolating the necessity of differentiating between general covariance, diffeomorphism invariance and background independence. A particularly important point of argumentation hinges on the intuitively background dependent formulation of special relativity as a theory in *dynamically* flat Riemannian geometry that satisfies the criterion for diffeomorphism invariance. Read also reviews familiar challenges to the idea of background independence via the absence of absolute objects and considers approaches to background independence within the same tradition based upon further ideas of fixed fields, absolute fields, and variational principles. He argues that in all cases when one confronts the definitions with concrete cases, their applications become delicate at best.

Two less traditional approaches to the problem come from the proposal of [Freidel and Teh \(2022\)](#) to base the definition of background independence of the existence non-trivial corner charges within a generally covariant action principle and of [Belot \(2011\)](#) to tie the definition to matching between geometrical and physical degrees of freedom. The first approach has the virtue of having a natural extension to the quantum theory but fails the basic requirement of adjudicating the simple case of diffeomorphism invariant special relativity in accord with intuitions. The second is taken by Read to be the most promising, and yet still suffers from the notable problem of involving definitions which are insufficiently tied to whether the fields and theory in question are fixed or dynamical. Within each model the geometrical structure in question may be dynamically inert and yet the theory be background independent according to the Belot proposal. Conversely, the geometric degrees of freedom need not be in one to one correspondence with physical degrees of freedom even in intuitively background independent theories such as general relativity ([Read 2024](#), pp. 34-5). Belot's approach to background independence is perhaps the most promising on the market, but still subject to what seems to be quite serious objections.

At this point, perhaps the question would be whether the literature classical background independence is developed enough to be extended into analysis of quantum theories of gravity. Read follows the discussion into this even more uncertain domain, and does impressive work in condensing discussions of background independence in the context of perturbative string theory, holography, and loop quantum gravity into a single chapter. When extended in quantum gravity the plethora of definitions further multiplies and some conclusions appear at first sight counterintuitive. The claims that perturbative string theory approach is, under some definitions, background independent, and loop quantum gravity approach is, under other definitions, simply not evaluable are well worth pondering. Such challenging, yet well-argued, conclusions will offer value in this book to scientists and philosophers working at the cutting-edge of quantum gravity, just as the earlier parts of the book will offer ample of interest to those interested in the foundations of the classical theory.

Notwithstanding undoubted formal and philosophical interests of these debates regarding background independence, in following the complex contours of decades of debate charted in this book it is difficult to avoid the feeling that something physically important has gone missing. Might the translation from the intuitive story of background independence into its formal representations have left us chasing a phantom? There seem to me to be available three distinct diagnoses of the situation, which we might label piecemeal explication, dissolution, and relationalism. The first approach is closest to that adopted by Read. We assume that there is an operative scientific concept of background independence in the neighbourhood of the approaches already set out, and seek to refine and clarify this concept piecemeal via different conditions, their revision, and their application. This approach has proved profitable in various areas of philosophy and foundations of physics over the last decades, and it may well prove worthwhile for generations of physicists and philosophers to pursue it further here. The second approach takes the opposite moral from the same story. If all we have to show from decades of work by the smartest philosophers and physicists around is an array of disparate criteria none of which is fully satisfactory, perhaps the project of defining background independence was not a well-posed one in the first place. Maybe we should conclude that there actually is not anything special about general relativity? Or background independence is simply an intuitive idea that we no longer need once we have full control over the relevant mathematics. Needless to say, this option would not be a particularly satisfactory one, but there is a lingering worry that it might not be reasonably discounted.

The final option, which is perhaps consistent with a direction of travel discernible in Read and Belot, is to take background independence as a three-place relation: A theory

is background independent relative to another theory if a certain class of objects which are identified as playing a ‘background role’ in the former do not play that role in the latter. The weakness of this approach is that we are no longer able to say that (for example) general relativity is background independent, independent of our comparison class. The virtue is that we might understand the sense in which general relativity is background independent relative to formulations of special relativity due to the differing roles of the metric, but background dependent relative to shape dynamics on account of the differing role of background spatial scale in the two theories. Furthermore, we can then say that (for example) the s-knot state formulation of Loop Quantum Gravity is background independent relative to a spin network state formulation of the theory but background dependent relative to the wider equivalence class of topologies that can be defined in Group Field Theory approaches (see (Rovelli 2004; Rickles 2005; Pooley 2006) on the first point and Oriti (2017) on the second). Whichever option is taken, Read’s work in this book will prove of undoubted lasting value.

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